TECHNOLOGY TRANSFER

JOINT HEARING

BEFORE THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

AND THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
U.S. SENATE

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CONTENTS

WITNESSES

September 4, 1986:

Page

- Ray G. Romatowski, Operations Manager, Albuquerque Operations Office, U.S. Department of Energy 7
- Dr. James Decker, Deputy Director of Energy Research, U.S. Department of Energy 8
- Dr. Erich Bloch, Director, National Science Foundation 29
- Dr. Siegfried S. Hecker, director, Los Alamos National Laboratory; and Irwin Welber, president, Sandia National Laboratories, Albuquerque, NM 93
- Jack B. McConnell, M.D., corporate director, Advanced Technology, Johnson & Johnson; Dr. John P. McTague, vice president—research, Ford Motor Co.; Don Silva, Science & Engineering Associates, Inc.; and Dr. Raymond Radosevich, dean and professor of management, Robert O. Anderson Schools of Management, University of New Mexico 148

Appendix—Additional material submitted for the record 191

TECHNOLOGY TRANSFER

THURSDAY, SEPTEMBER 4, 1986

House of Representatives, Committee on Science and Technology; and U.S. Senate, Committee on Energy and Natural Resources, Subcommittee on Energy Research and Development,

Washington, DC.

The committees met in joint session, pursuant to notice, at 9:20 a.m., at the Convention Center, Albuquerque, NM, Hon. Pete V. Domenici (chairman of the Senate Subcommittee on Energy Research and Development) presiding.

Senator Domenici. Good morning. The hearing will please come to order.

Let me first apologize. It seems to us up here that something is wrong with the lighting, but we can't do anything about it. You're in the light and we're in the dark, and the more I think of it, that might be quite apropros. [Laughter.]

This is a hearing of two committees of the Congress, one from the U.S. Senate and one from the U.S. House. On the Senate side, the Energy Committee has a Subcommittee on Research and Development, which I chair. Senator Bingaman is on the committee, and so we are here in that capacity.

Our good friend, Congressman Lujan, is the ranking member of the House Committee on Science and Technology, and he joins us here in that capacity, representing that committee. Is that correct, Manny?

Mr. Lujan. Correct.

Senator Domenici. And so what we will do is we will proceed in the normal manner that we would official hearings. We don't have a lot of time. Nonetheless, we want to accomplish what we set out to do and to hear what the witnesses desire to discuss with the Congress through the committees that are represented here.

Our normal approach is that we have some opening statements that set the parameters for why we are having the hearing, and with your indulgence and the indulgence of the three witnesses who are already seated, we're going to have brief opening statements and then we'll proceed to the witnesses.

I think what I will do is yield to the Congressman for opening remarks on his part, then to my friend, Senator Bingaman, and then I will have brief opening remarks and we'll proceed with the witnesses.

Congressman Lujan.

Mr. Lujan. Thank you very much, Senator Domenici and Mr. Chairman, and Senator Bingaman. I am pleased to join you at this hearing in conjunction with the Focus '86 Conference. The conference is properly named and held in 1986 because throughout the 99th Congress our focus has been on technology transfer.

Commercialization of Federal laboratory technology has been of great interest to the Science and Technology Committee for a long time. For nearly a decade, we have promoted mechanisms whereby the fruits of basic research, funded by taxpayer dollars, can be disseminated to the American industrial enterprise, thereby enhancing our economy and advancing the United States in the world marketplace.

More recently, the Science Committee has been eager to cooperate with the Reagan administration in fostering cooperative relationships with industry and with the Federal Government and the U.S. academic institutions. We have witnessed an increase in such arrangements particularly through the National Supercomputer Centers and the Engineering Research Centers sponsored through the National Science Foundation and Dr. Bloch. As recently as 1985, the President's Commission on Industrial Competitiveness issued a study on global completion which highlighted the fact that U.S. technology is and has been our strongest competitive advantage. Some 18 billion of Government-sponsored R&D, nearly one-third of the total, is conducted in our Federal laboratories, of which there is more than 700.

Over the years, these labs have produced over 28,000 Federal patents, but only 5 percent of them have been licensed. It's no wonder, then, that the Congress has taken an interest in seeing to it that incentives are present within the Federal Government to transfer this wealth of technology. I have always been of the opinion that all Federal research, except classified defense research, of course, should end up in the private sector somehow.

It's the goal of this hearing to examine technology transfer issues from the standpoint of both public and the private sector. I am grateful to the witnesses who will appear before this Committee today for their interest and the commitment they have shown.

Further, I am interested in exploring how various Federal agencies and labs can encourage technology transfer while maintaining the integrity and mission they have been chartered with. For example, the Department of Energy has the authority to issue waivers on patents so that the private sector can make use of certain inventions. Very few waivers have been issued, and those that have been issued have taken a relatively long time. So I hope that we can address this topic and come to a better understanding of the DOE role in technology transfer.

With that, Mr. Chairman, I look forward to a very productive and thought-provoking hearing. Thank you very much.

Senator **Domenici**. Thank you very much, Congressman Lujan.

Senator Bingaman.

Senator **Bingaman**. Thank you very much, Senator, and Congressman Lujan. I appreciate the chance to be here, and I commend both of you for holding the hearing.

My concerns are the same as those that Congressman Lujan just expressed, and I am sure Senator Domenici will also discuss, and that is how do we take the tremendous investment that we're making in our national laboratories, and in our defense research in particular, and use that to get the commercial benefits that are needed in order to keep this country in the position it needs to be in in the world economy.

The Federal Government today contributes over $50 billion annually to research and development, which is about half of the total national investment in research and development. If you add both the contractor-operated and the Government-operated laboratories together, we have about 18 billion dollars that we are spending in the Federal Government on our national laboratories. We employ about one-sixth of the nation's scientists and engineers in those laboratories.

I think the issue, as Congressman Lujan said, is how do you get the maximum possible transfer or benefit from that enormous investment that's being made, questions like are we overly sensitive to the defense nature of some of the information, are we—have we been too reluctant to allow that information to be used in a commercial setting. Clearly the issues have been addressed now for many years. We have the Dole-Bayh Patent and Trademark Amendments that were passed in 1980, and we have the Stevenson-Wydler Act. We have proposed amendments to that which have gone through both Houses and are awaiting final action.

I guess I am interested in seeing what kinds of specifics we could identify this morning in the way of legislative changes that are needed if the problem is one of legislative obstacles, or just if it's administrative, what can we do more effectively in an administrative way to try to ensure that this tremendous resource that we have here in the national laboratories in particular and in our defense research establishment is used for the benefit of the entire economy. So again, I appreciate the chance to be here.

Thank you, Mr. Chairman.

Senator **Domenici**. Thank you very much, Senator.

I had a prepared statement. I would just make it a part of the record, if there's no objection.

[The prepared opening statement of Senator Domenici follows:]

OPENING STATEMENT - SENATOR DOMENICI

TECHNOLOGY TRANSFER HEARING - SEPT. 4, 1986
ALBUQUERQUE, NEW MEXICO

GOOD MORNING. IT IS A PLEASURE TO JOIN MY COLLEAGUES FROM THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY IN PRESIDING OVER THE HEARING THIS MORNING TO CONSIDER ISSUES AND LEGISLATION RELATING TO TECHNOLOGY TRANSFER.

IN THE 1985 "REPORT OF THE PRESIDENT'S COMMISSION ON INDUSTRIAL COMPETITIVENESS," THE COMMISSION STATES THAT:

> "THE U.S. POSITION AS A WORLD LEADER, THE ABILITY TO PROVIDE A RISING STANDARD OF LIVING FOR OUR PEOPLE, OUR NATIONAL SECURITY, AND THE ABILITY OF GOVERNMENT TO FUND DOMESTIC PROGRAMS -- ALL THESE GOALS DEPEND ON THE ABILITY OF AMERICAN INDUSTRY TO COMPETE BOTH AT HOME AND ABROAD."

ONE OF THE RECOMMENDATIONS MADE BY THE COMMISSION AS A MEANS TO STRENGTHEN OUR COMPETITIVE PERFORMANCE WAS TO "CREATE, APPLY, AND PROTECT TECHNOLOGY". IN THE COMMISSION'S OPINION, INNOVATION IS A VITAL INGREDIENT FOR SPURRING NEW INDUSTRIES AND REVIVING MATURE INDUSTRIES. THEY RECOGNIZED THE IMPORTANCE OF TECHNOLOGICAL ADVANCES AS A MEANS TO IMPROVE PRODUCTIVITY AND COMPETITIVENESS IN THE MARKETPLACE.

IT IS WIDELY RECOGNIZED THAT THE RESEARCH AND DEVELOPMENT PROGRAMS OF THE FEDERAL GOVERNMENT, FUNDED AT OVER $20 BILLION PER YEAR, AND CARRIED OUT BY A NETWORK OF FEDERAL LABORATORIES

LOCATED THROUGHOUT THE NATION, CAN CONTRIBUTE A LOT TOWARDS TECHNOLOGY ADVANCEMENT IN THE PRIVATE SECTOR. BUT THE KEY TO THIS EFFORT IS EFFECTIVE TRANSFER OF THE FEDERALLY-SPONSORED TECHNOLOGIES INTO THE HANDS OF COMMERCIAL END-USERS.

THE STEVENSON-WYDLER ACT OF 1980 MARKED THE BEGINNING OF A CONCERTED EFFORT ON THE PART OF THE FEDERAL GOVERNMENT TO PROMOTE TECHNOLOGY TRANSFER FROM THE FEDERAL LABORATORIES. NOT ONLY DID THIS ACT RECOGNIZE TECHNOLOGY TRANSFER AS A MANDATED RESPONSIBILITY OF THE FEDERAL GOVERNMENT, IT ALSO ESTABLISHED AN OFFICE OF RESEARCH AND TECHNOLOGY APPLICATION WITHIN EACH LAB TO DISSEMINATE INFORMATION AND EXPERTISE.

RECOGNIZING THAT PATENT RIGHTS WERE KEY TO COMMERCIALIZATION OF TECHNOLOGIES, THE CONGRESS ALSO MADE CHANGES TO THE PATENT LAWS IN ORDER TO MAKE IT EASIER FOR INVENTORS OR PRIVATE FIRMS TO OBTAIN EXCLUSIVE LICENSE FOR DEVELOPMENT OF A CERTAIN TECHNOLOGY, IDEA, OR PRODUCT.

PENDING LEGISLATION NOW BEFORE CONGRESS -- H.R. 3773 -- WILL MAKE FURTHER IMPROVEMENTS TO THE TECHNOLOGY TRANSFER PROCESS, BY ESTABLISHING A FEDERAL LAB CONSORTIUM WITHIN THE NATIONAL BUREAU OF STANDARDS, AND BY ENCOURAGING LABS TO ENTER INTO COOPERATIVE RESEARCH PROGRAMS WITH INDUSTRY, UNIVERSITIES, AND STATES.

WHILE PROGRESS HAS CLEARLY BEEN MADE IN THE FRONTIERS OF TECHNOLOGY TRANSFER, I AM SURE THAT EVERYONE HERE TODAY IS VERY MUCH AWARE OF HURDLES THAT STILL MUST BE SURMOUNTED IN ORDER TO REAP THE FULL BENEFITS OF THE TECHNOLOGY TRANSFER PROCESS. ONE

NEED ONLY LOOK TO THE POOR TRACK RECORD FOR PATENT UTILIZATION IN THE FEDERAL GOVERNMENT TO REALIZE THE MAGNITUDE OF THE PROBLEM: ONLY 5% OF THE PATENTS DEVELOPED IN THE FEDERAL GOVERNMENT ARE ACTUALLY UTILIZED BY THE PRIVATE SECTOR. THIS COMPARES TO A 33% PATENT-UTILIZATION RATE WITHIN PRIVATE INDUSTRY.

THE PROBLEMS IN TECHNOLOGY TRANSFER ARE EVEN FURTHER IRRITATED WHEN IT COMES TO WEAPONS-RELATED LAB WORK, WHERE THE GOVERNMENT IS EXTREMELY PROTECTIVE OF THE SENSITIVE NATURE OF THE RESEARCH. I FIRMLY BELIVE THAT THESE PROBLEMS CAN BE OVERCOME, AND THAT TRANSFER OF DEFENSE-RELATED TECHNOLOGIES TO THE PRIVATE SECTOR WOULD GO A LONG WAY TOWARDS ENHANCING THE IMAGE OF THE WEAPONS LABS IN THE EYES OF THE PUBLIC.

THIS HEARING WILL PROVIDE US WITH AN OPPORTUNITY TO AIR THESE AND MANY OTHER ISSUES RELATED TO TECHNOLOGY TRANSFER, SO THAT WE CAN IDENTIFY AND RESOLVE THE REMAINING WEAKNESSES THAT PREVENT THE TECHNOLOGY TRANSFER PROCESS FROM REACHING ITS FULL POTENTIAL.

Senator **Domenici**. From my standpoint, just to make the point, I am willing to admit that we are doing a little better in technology transfer, in the areas that we are talking about, our nationally-funded laboratories—moving their research into applied technology and products—than we were, say, 10 years ago. But I think it's fair to say that we're still not doing very well. As a matter of fact, looking at it in an objective manner, not knowing of the builtin impediments and cultural inhibitions, I'm sure that most observers would say we are doing very, very poorly in terms of the amount of resources going into research and the amount of technology and product coming out, even if one assumes that the principal motivation for the funding is not the technology that is to be applied. There ought to be substantially more consumer products and know-how that come from that research.

Frankly, I think that there are a lot of reasons why technology transfers do not occur more often. We have to find better ways for the transfer process to work. From my standpoint, I would say to those who are in our laboratory system, I think you have to help us and I think we have to help you, and business has to help all of us. If we don't do better, I really have a strong feeling that because of the enormous amount of money being spent, that there will begin to grow in the business community, a negative attitude as to why so much money is being spent with so little results. I already hear some of that. If the business community was doing better themselves, I think they would have a better complaint. But they seem to have some inhibitions, too. They may even be cultural within big businesses, that they just can't convert research within the bureaucracy of a big business to a new product. But, nonetheless, I hope we explore a number of those things before we are finished. The Congressman has aptly stated, we don't need any more commissions. The President's commission is a very objective one and it states the point. We are lagging in a very dangerous manner in terms of applying the enormous scientific and educational advantage that we have to the marketplace.

With that, let me welcome the witnesses. There's just a slight change in the agenda. Ray Romatowski, the manager of the Albuquerque Operations Office of the Department of Energy is here. He will have a brief opening statement and introduce our first witness, and then we will proceed on schedule.

Ray, we welcome you here.

STATEMENT OF RAY G. ROMATOWSKI, OPERATIONS MANAGER, ALBUQUERQUE OPERATIONS OFFICE, U.S. DEPARTMENT OF ENERGY

Mr. **Romatowski**. Thank you, Mr. Chairman, Senator Bingaman, Congressman Lujan. I appreciate the opportunity to introduce Dr. Decker and just make a few short remarks about the progress hopefully that's being made in this very difficult area.

As you know, the three weapons laboratories are closely tied into a production plan system for the manufacture of nuclear weapons, and two of those three laboratories are here in New Mexico. That provides some very special type problems for us here that some of the other national laboratories do not necessarily have.

All of us are very hopeful—and I think you'll find from the testimony of the two lab directors and from Dr. Decker—that the Department is very much committed to move technology out into commercialized sectors of this country and to do so as swiftly and as efficiently as we can. All of us are hopeful that, with the changes in statutes which have taken place over the last several years, the changes in internal regulations within the executive branch, and some of the new feeling within the Department of Energy, that this movement toward a faster commercialization of applicable technology can in fact be enhanced.

I think we're especially honored today to have Dr. Jim Decker with us. Dr. Decker has worked very closely with all of the national laboratories in the Department of Energy, and particularly with the two weapons laboratories here in New Mexico. I consider him a very strong advocate of technology transfer and a particularly good friend of the laboratories here.

So it is with a great deal of pleasure I introduce Dr. Decker.

Senator **DOMENICI**. Thank you very much, Ray.

Dr. Decker, would you proceed.

STATEMENT OF DR. JAMES DECKER, DEPUTY DIRECTOR OF ENERGY RESEARCH, U.S. DEPARTMENT OF ENERGY

Dr. **DECKER**. Thank you, Mr. Chairman.

I'm pleased to have the opportunity to represent the Department of Energy at this hearing on technology transfer. With your permission, I would like to submit my written statement for the record and proceed with some oral remarks.

Senator **DOMENICI**. It'll be made a part of the record.

Dr. **DECKER**. Thank you.

First I want to echo some of the comments that have already been made this morning.

The transfer of technology from federally supported research and development programs to the private sector is an extremely important activity. As was pointed out by the President's Commission on Economic Competitiveness—and I quote—"Technology propels our economy forward. Without doubt, it has been our strongest competitive advantage." End of quote.

The research and development capability of this country is still unequaled in the world. However, we must take full advantage of this strength by ensuring that the fruits of our research and development are exploited by U.S. industry and turned into American-made products. The effective transfer of technology from federally sponsored research to U.S. industry is of particular importance, since federally sponsored research represents about 50 percent of all the research in this country.

Albuquerque is certainly an appropriate place to hold this hearing because of the leadership New Mexico is showing in technology transfer. Last spring, Ray Romatowski set up a series of briefings and meetings for me on some of the technology transfer and economic development efforts here in New Mexico. I heard about the activities of the Rio Grande Research Corridor, Technet, and Riotech. I talked with a number of people working on these activities from the University of New Mexico, the business community, Los

Alamos National Laboratory, Sandia National Laboratory, and the Albuquerque Operations Office. If these activities are successful, as I hope they will be, then they will serve as a model for economic development for other areas of the country.

The Department has been supporting a strong technology transfer effort by its laboratories. This year, as part of the annual laboratory planning process, Secretary Herrington's policy guidance memorandum to the multiprogram laboratories stressed the continuing importance of technology transfer, praised the laboratories' progress, and urged them to redouble their efforts.

In talking about some of the Department's activities, I will use the term technology transfer in the broadest sense, namely, technology transfer is a transfer of know-how. There is no clear, tested model that an organization can follow and be guaranteed success in technology transfer. There are many avenues of transfer, ranging from simple personnel exchanges between our laboratories and industry, to licensing patents resulting from laboratory work. I believe that almost every situation is different and there is a need for creative—for flexibility and creativity—in approaching the problem.

The Department and its predecessor agencies have had some remarkable technology transfer successes. A few examples are nuclear medicine, nuclear power, supercomputer technology, ion implantation and others. Nuclear medicine perhaps is a very good example, since a large percentage of research in nuclear medicine has been funded by the Department and its predecessor agencies, starting back with the Atomic Energy Commission. The use of radioisotopes in medical examinations has provided major advances in diagnosing diseased organs, including the heart and the brain. In 1982, there were about 7½ million nuclear examinations in this country alone.

In addition to the obvious direct human benefits of nuclear medicine procedures, these developments have also created a substantial industry that supplies radioisotopes and nuclear medicine equipment. I am pleased to note that the week of July 27 of this year was designated National Nuclear Medicine Week by Congress.

One aspect of the Department's unique role in the Nation's scientific enterprise is the construction and operation of large scientific research facilities for use by the whole U.S. scientific community. These are large, expensive state-of-the-art facilities that are not available in industrial research laboratories or universities because of their large size and cost. These facilities include such things as synchrotron light sources, research reactors, the combustion research facilities, and various accelerators. These so-called user facilities provide a tremendous resource for the scientific community and offer an environment in which industry, university and laboratory personnel work side by side. In the process of using these facilities, industrial researchers learn about related new technologies developed in DOE laboratories and in universities as well.

The use of DOE user facilities by industry has expanded in recent years. In 1985, over 500 industrial users, representing 225 companies, made use of these facilities, almost twice the number recorded from 1981.

I will mention just two examples of industrial use. At the National Synchrotron Light Source in Brookhaven, computer manufacturers have been attracted to do advanced work on using x-ray lithography to build smaller and more powerful computer chips. Another example is the combustion research facility at the Sandia National Laboratory in Livermore. Their laser diagnostic techniques and computer codes for understanding combustion in engines to improve both efficiency and reduce pollution have attracted the involvement of U.S. auto manufacturers.

In the area of personnel exchanges, we have started the Industry Technology Exchange Program. And, Senator Domenici, we appreciate your help and encouragement in getting that program started.

This program brings industry researchers to the DOE laboratories to work with scientists and engineers on technology problems of particular interest to their company. These appointments are cost shared with the company and last 6 months or more. We find this program effective in establishing strong laboratory-industry partnerships and in providing industry researchers with direct experience with laboratory scientists and resources.

I want to quickly cover several more steps that the Department and its laboratories have taken in recent years to improve technology transfer. Some laboratories have instituted more liberal policies that allow employees to do more consulting for industry. This has proven to be a useful technology transfer mechanism. The Department has also enacted class patent waivers covering all its user facilities in non-DOD work performed at the DOE laboratories. These waivers allow companies who use our facilities for contract for work to be done in our laboratories to retain patent rights.

Several laboratories have also instituted a liberal leave policy that allows a scientist or engineer to take leave and go off and try to start a company on his own.

Senator **Domenici**. When did the waiver policy start?

Dr. **Decker**. Back, I believe, in 1982 and 1983.

Senator **Domenici**. How many waivers have been granted?

Dr. **Decker**. For companies using our user facilities, that I don't know. They automatically go to the industrial company, so I'm not even sure that we have a record of that. But I can try to find out for you and provide it for the record.

[The information follows:]

The patent waiver covering inventions derived from research conducted at DOE user facilities is a class waiver. This waiver, granted by DOE in 1983, gives public and private users of DOE's large scientific facilities automatic rights to patents derived from experimental research performed at these facilites. DOE has literally thousands of outside scientists using the more than 100 user facilities located at various DOE sites. Since these outside users are given automatic rights to patents under this class waiver, DOE does not keep tract of individual patents derived from user facilities.

Senator **Domenici**. I believe there are very few, but we'll find out.

Dr. **Decker**. In recent years, the Department's technology transfer efforts have been influenced by several Congressional actions, including the Stevenson-Wydler Act and the Bayh-Dole Act. Stevenson-Wydler helped to raise the visibility of technology transfer and helped focus the laboratory activities. The Bayh-Dole Act of 1980 gave nonprofit and small business contractors rights to patents developed under DOE contracts. In 1983, an executive order permitted agencies to extend patent provisions to other contractors, such as for-profit contractors, to the extent possible within agency authority.

The 1984 amendment to the Bayh-Dole Act extended authority for nonprofit and university contractors managing Government-owned, contractor-operated laboratories to elect to retain patent rights. The Department and its laboratories, aided by Congress, have taken a number of steps to improve technology transfer. However, it is important to remember that technology transfer from the DOE laboratories to U.S. industry takes two willing partners. As I have described it, the Department and its laboratories have taken many steps to make technology available. However, U.S. companies must be willing to make the investments to develop products from new technologies in order for our efforts to be truly successful.

A willingness to invest in new technologies often requires a company to make substantial financial commitments to development and new capital equipment. Often, a longer range view is required on the part of company management and investors. In short, the business environment in the country is a very important ingredient.

In summary, I have described a number of significant steps that have been taken in recent years to improve technology transfer from the Department's laboratories to U.S. industry. Some of these steps are already bearing fruit. However, as I indicated earlier, there is no blueprint to follow for successful technology transfer. Technology transfer occurs through many different paths. We need to continue to explore those paths and vigorously pursue the ones that we determine to be most effective. Of course, we should not lose sight of the fact that a successful transfer of technology to industry requires continuation of strong Federal research programs.

Mr. Chairman, that concludes my oral remarks.

[The prepared statement of Dr. Decker follows:]

Statement of Dr. James Decker

Deputy Director of Energy Research

Department of Energy

Before the

Subcommittee on Energy Research and Development
of the
Senate Committee on Energy and Natural Resources

and the

House Committee on Science and Technology

September 4, 1987

Introduction

Mr. Chairman and members of the Committee, I am pleased to appear before you today to discuss the Department of Energy's (DOE's) technology transfer efforts.

The Department of Energy, and its predecessor agencies - the AEC and ERDA, have a long history of transferring technology developed as a part of their mission research programs. Since the enactment of the Atomic Energy Act of 1954, DOE and its predecessor agencies have included technology transfer as a part of their program research efforts. Nuclear power, nuclear medicine, radiation processing, and ion implantation are a few of the widely known examples of the technology applications derived from the Department's mission research. However, there is much more to our technology transfer successes than these examples.

I should start by saying that technology transfer and subsequent commercialization is a very complicated process. After an idea has been carried through from conception to proof-of-concept, the difficult tasks of identifying and evaluating potential markets, attracting sufficient financial resources, and overcoming scale-up and manufacturing problems must still be undertaken by industry. This process involves high risk, long lead times, and many opportunities for failure. In moving technology out of the laboratory, industry must be convinced that the often costly development required for a commercial product or process is worth the risk involved. Even when this occurs, the likelihood of success may still be low. The point is that when technology transfer does occur it is because the technology involved appears to be relatively attractive to industry and that successful transfers - those that lead directly to profitable commercial products or processes - may require many years and are the exception rather than the rule.

The Department carries out its R&D missions through a system of government laboratories, universities, and private industry. Technology transfer is an important concept that is integrated throughout this system. This is especially true for near-term technology areas such as conservation and renewable energy. Technology transfer is also a very important part of those DOE laboratories involved in basic R&D missions.

The Department of Energy has a broad range of technology transfer activities and accomplishments that are resulting in exciting new business opportunities for U.S. industry and new and better technology products for the nation and the world. I will limit my remarks to the Department's technology transfer efforts that are concentrated at DOE laboratories, which have primary responsibility for carrying out the Department's R&D programs. The scientists and engineers actually conducting the R&D at our laboratories have the best opportunity to identify and pursue technologies having potential commercial applications in the private sector. Due to the extent of the science and technology research carried out by the Department through its extensive laboratory system, DOE should be a leader in the federal government in the transfer of scientific and technical knowledge to the industrial and academic research communities in the United States.

Legislation

The technology transfer legislation of the past 6 years has aided the Department in its technology transfer activities.

The Stevenson-Wydler Technology Innovation Act of 1980 required our laboratories to set up Offices of Research and Technology Applications (ORTA) to facilitate technology transfer and required that 0.5% of our research budget be directed toward technology transfer objectives. Since its passage, our laboratories have made great progress in identifying promising "spin-off" technologies. The ORTAs have helped foster an environment within the laboratories that encourages researchers to consider potential technology applications and has helped make ongoing laboratory research efforts better known to U.S. firms.

The Bayh-Dole Act of 1980 gave non-profit and small business contractors rights to patents developed under DOE contracts. While this applied to DOE contracts with universities, non-profits, and small businesses, it did not apply to our government-owned, contractor-operated (GOCO) laboratories. A 1983 Executive Order permitted agencies to extend patent provisions to other contractors, such as for-profit contractors, to the extent possible within agency authority. The DOE enacted class patent waivers covering all its user facilities and non-DOE work performed at the laboratories in 1982 and 1983. We were also in the process of developing similar waivers covering many areas of nonclassified work at our Laboratories when the 1984 amendment to the Bayh-Dole Act extended authority for non-profit and university contractors of GOCO laboratories to elect to retain patent rights. This amendment applies to 7 of our 9 multiprogram laboratories, which collectively perform 90% of the Department's laboratory R&D. It is only recently, however, that the regulations for implementing the Bayh-Dole amendments have been promulgated. On July 14, the Department of Commerce published them for final comment. We expect to be implementing patent class waivers covering many areas of work at our laboratories. In the interim, the Department will continue its practice of waiving patent rights to laboratory contractors on individual inventions so that U.S. industry can continue take full advantage of licensing new technologies from the laboratories.

DOE Technology Transfer Policy

The Department continues to support a strong technology transfer effort as part of its R&D strategy. In particular, the National Energy Policy Plan identifies two key R&D objectives directed at cooperation with industry:

- To sponsor cooperatively with industry long-term, high-risk research efforts that are unlikely to be undertaken alone by the private sector.

- To facilitate the effective transfer of technology, making the results of research available widely and promptly in the marketplace.

Policy guidance is provided to the multiprogram laboratories through the institutional planning process. Through this process, plans and strategies for improving interactions with industry and universities are developed and communicated. Part of this planning cycle includes an annual policy guidance memorandum from the Secretary to the multiprogram laboratories. In this year's memo, Secretary Herrington stressed the continuing importance of technology transfer, praised the laboratories' progress and urged them to redouble their efforts.

The DOE R&D Laboratory Technology Transfer Program, managed by the Office of Energy Research, was implemented in response to the Stevenson-Wydler Act. The program is responsible for establishing the institutional policy framework for technology transfer to the public and private sectors and for coordinating and monitoring the technology transfer programs of the DOE laboratories. Each laboratory has flexibility to implement technology transfer activities in the most suitable fashion for its own mission and organizational circumstances consistent with Departmental policy.

Note, however, the DOE is required under the Nuclear Non-Proliferation Act and the Atomic Energy Act to prevent the proliferation of nuclear materials, nuclear weapons and selected technologies. There are also legal responsibilities which require that technology, including that originating in the weapons laboratories, not be exported unless specific criteria are met. Any encouragement of technology transfer must be viewed, then, in light of the Department's commitment to the U.S. national and international obligations to prevent technology transfer should it have potential proliferation effects.

The Department will continue to protect national security information developed through the research and development activities at the national laboratories. Specifically, the DOE will continue to protect technical information developed under the nuclear weapons program, the uranium enrichment program and the naval nuclear propulsion program. This protection will involve defining exceptional circumstances in the regulations for classified and unclassified controlled nuclear information (UCNI). It is essential that this policy be followed to ensure we uphold our national security obligations.

DOE Activities

DOE technology transfer occurs as an integrated part of our mission programs. Therefore, technology transfer is an ongoing part of the Department's R&D that is incorporated within research efforts throughout the various DOE programs. The responsibility for coordinating technology transfer through the laboratories is handled through the DOE Office of Energy Research.

The common working definition of technology transfer is the transfer of federally-developed technology to the private sector. The Department believes that the transfer of scientific knowledge to the research community is an important way in which scientific advances permeate the science community, eventually leading to new technologies and products. Programs within the Office of Energy Research emphasize knowledge transfer and include programs directed at university cooperation, industry cooperation, and sharing of laboratory facilities.

Before I outline some of the technology transfer activities directed primarily at industrial participation, I would like to highlight two important activities emphasizing how the DOE programs interact with the academic community and the science community as a whole.

The first is our university programs which are designed to assist university faculty and student research by providing them with the unique resources of the DOE laboratories. The laboratories provide research and educational opportunities for students and faculty, support collaborative research programs between laboratory and university researchers, and provide benefits and assistance to nearby colleges and universities. Typically, the larger multiprogram laboratories will each have about 1,000 university faculty and students in residence for all or part of a year participating in a variety of programs. For example, Argonne National Laboratory operates eight programs for visiting faculty, eleven for graduate students, six for undergraduate students and three for high school teachers and students. These programs allow faculty and students to take advantage of facilities and resources not often available at most universities and aid in the transfer and sharing of scientific knowledge within the research community.

The second is the DOE user facilities, located at our various laboratories throughout the United States. These facilities are typically very large, advanced scientific research facilities that are made available to the scientific community in order to perform research experiments on specialized equipment that is often unavailable elsewhere in the United States or the world. User facilities provide a tremendous resource for the scientific community and offer an environment in which industry, university and laboratory personnel work side-by-side.

Interest in, and use of, DOE user facilities by U.S. industry has expanded. The National Synchrotron Light Source at Brookhaven National Laboratory has attracted U.S. computer manufacturers to do advanced work on using x-ray lithography to build smaller and more powerful computer chips, which will help make U.S. firms more competitive in world markets. The Combustion Research Facility at Sandia National Laboratory at Livermore has attracted the involvement of U.S. auto manufacturers with its laser diagnostic techniques and computer codes for understanding engine combustion. Other notable examples are the National Center for Electron Microscopy at Lawrence Berkeley Laboratory and the High Flux Isotope Reactor at Oak Ridge National Laboratory.

DOE technology transfer activities directed primarily at industrial participation have many components. As I mentioned earlier, technology transfer typically occurs as an integrated part of our mission research programs, while the R&D Laboratory Technology Transfer Program acts as a focal point for laboratory activities. I will highlight just two activities in this Program.

The Industry Technology Exchange Program brings industry researchers into the laboratories to work with scientists and engineers on technology problems of particular interest to their company. These appointments are cost-shared with the company and last 6 months or more. In one example, researchers at Boise-Cascade have begun to solve corrosion problems in the pulp and paper industry as a result of a research appointment at Pacific Northwest Laboratory. This collaborative effort is resulting in the application of new systems which, if successful and implemented widely, could save the pulp and paper industry millions of dollars per year. We find this program extremely effective in establishing strong laboratory-industry partnerships and in providing industry researchers with direct experience with laboratory scientists and resources.

The DOE Technology Transfer Program also undertakes analysis of issues or problems of special interest. One such analysis involves an effort by DOE and the labs to find better ways in which to measure and evaluate their ability and their degree of success in transferring technology. This effort has led to the development of an initial set of measures that the laboratories will use to gauge the effectiveness of their technology transfer efforts. Through this method, DOE hopes to identify and expand upon successful transfer mechanisms while deemphasizing those that have been less successful.

Accomplishments

The progress made by the DOE laboratories in technology transfer has been impressive. We have seen a continual growth of laboratory activities and successes and we expect to see much more in the future. Many of our laboratory directors have become personally involved in, and committed to, using laboratory resources to help industry and universities.

Our laboratories continue to be leaders in federal technology transfer efforts. The Chairman of the Federal Laboratory Consortium, as well as four out of six of its Regional Coordinators, are representatives from DOE laboratories. This year DOE laboratories were awarded 21, or one-fifth, of the IR-100 awards, which recognize the most significant technology products and processes with market potential. Six of these were awarded to Sandia National Laboratory - the most awarded to any organization. Last year the DOE laboratories were awarded 21 citations. In fact, since 1981 DOE laboratories have accumulated over 100 of these awards. Similarly, in 1985, 17 of the Science Digest top 100 innovations were attributed to DOE laboratories.

A review of our large multiprogram national laboratories provides some rough data that reveals an impressive technology transfer record. In 1981, 260 industrial users representing 111 different companies participated in experiments at our DOE user facilities. By 1985, this type of participation nearly doubled to 513 industrial users representing 225 companies.

We have also made impressive progress in pursuing collaborative research projects with industry. In 1981, we had 17 collaborative projects with industry totalling $2.5 million. Last year, we had 44 collaborative projects totalling $16.3 million. That's more than a doubling in the number of projects and over a six-fold increase in dollar value. These collaborative projects are undertaken on a jointly-funded or cooperative basis with industry and represent an industry-government partnership that utilizes the laboratory resources.

In 1981, seven new companies were started that were based on technology developed within the laboratories. In 1985, 27 new companies were formed based on technology spin-offs from DOE laboratories. In addition to new company starts, 244 separate technologies were transferred to existing firms in 1985 compared to 179 in 1981.

The data I have presented, which is representative of just our nine multiprogram national laboratories, reveals two important points. First, the Department of Energy and its laboratories have made impressive improvements in their technology transfer and scientific interactions with industry over the past five years. Second, the Department and its laboratories have historically had a strong technology transfer effort that resulted in important transfers to industry. We fully anticipate that this solid performance will continue over the next five years and that our laboratories will continue to be leaders in federal technology transfer efforts.

Some excellent transfers are facilitated through our work-for-others activities. A recent example is the 10-Meter Telescope Project at Lawrence Berkeley Laboratory with the Keck Foundation and the California Institute of Technology. Laboratory scientists are designing and constructing the supports for 36 segments which make up the telescope mirror, the systems for continously checking the alignment of the mirror, the computer control system, and the mechanisms for making fine adjustments to the position of mirror segments. This new design allows construction of a telescope with four times the light gathering power of any other ground based telescope.

I would like to give another example of a laboratory transfer to demonstrate the extent of the DOE laboratory effort and to indicate the difficulty and importance of the individual efforts involved.

Amtech Corporation is a small business spin-off based on work conducted at the Los Alamos National Laboratory. In the late 1970's, the Department of Agriculture sponsored research to develop a passive method of electronic identification applicable to livestock. The passive circuitry required no power source and could provide identification information when accessed by a nearby radio transmitter. In 1978 this technology won an IR-100 award.

Laboratory efforts to interest companies in adopting this technology for commercial use, by making the underlying DOE patents available for licensing, were unsuccessful. Despite this, laboratory researchers began working on their personal time to develop a business plan with the assistance of graduate students from the University of New Mexico's Technical Entrepreneurship course. Through this effort, other technology applications were identified, such as vehicle and railcar identification and warehouse inventory systems, which appeared to have greater market potential.

The DOE and the University of California granted ownership of two relevant patents to laboratory employees who were founders of Amtech. Amtech was in turn reassigned these patents, which were viewed as vital to attracting seed financing and establishing market alliances. Seed capital was obtained by Amtech in 1984 from a computer software company interested in expanding its market. One scientist left the laboratory to devote full time to Amtech while two others were granted leaves-of-absence to assist with commercial development. In addition, two other scientists worked part-time for the laboratory and part-time for Amtech.

Amtech now employs 13 people and is located in the Los Alamos Small Business Center, the first business incubator facility in New Mexico. While small in size, Amtech's impact on the business community is widespread. Component parts and services are purchased from small vendors in Ojo Caliente (a small town in economically depressed northern New Mexico), Albuquerque, Los Alamos, Minneapolis, California, Pittsburgh and a border manufacturing plant in Mexico. Customers include domestic railroads, coal companies, and port authorities, as well as foreign railroads.

Amtech is addressing a wide market with its technology, including electronic identification for railcars, intermodal containers, and trucks, and automated systems for highway toll collection and inventory control as potential applications. Current business plans estimate that Amtech will be a multi-million dollar business employing over 100 people by 1988.

As you can see, the complexity and time/input of transforming just one laboratory project to a successful commercial venture are enormous. DOE and laboratory employees had to overcome a number of obstacles, and it has taken over 8 years for the laboratory technology to begin to make its way into commercial markets. DOE granted ownership of two related patents, the laboratory allowed leaves-of-absence for the employees and then loaned Amtech electronic identification equipment at a crucial time in its business start-up phase.

I would like to now move on to highlight the directions DOE will pursue in technology transfer during the coming years.

Future Plans

The Department will continue to encourage technology transfer and knowledge transfer as part of its mission research programs and through the established technology transfer programs at its laboratories. We will work closely with industry to identify laboratory technologies that have potential commercial applications. The Department will pursue a broad range of activities directed at making U.S. industry aware of the technology resources available at the DOE laboratories.

In the near term, there are several aspects of the Department's technology transfer efforts that will receive additional emphasis.

First, we will encourage our laboratories to work with companies, universities, and governments located in their states and geographic regions. We recognize and appreciate the regional economic impact our large laboratories have on nearby businesses and governments. Many of these are natural relationships from which both the laboratory and the region can benefit through mutual assistance and consultation.

Second, we would like to see the laboratories explcre ways to better assist small businesses. We would like to duplicate the success the laboratories have had in transferring technologies to large industrial companies with the smaller-size companies. While the larger firms are often more equipped to provide the resources necessary to move a technology toward commercialization, small businesses provide an important economic resource and should be brought into the laboratories' technology transfer efforts.

Third, we will be involved in the implementation of the patent class waivers for our contractor-operated laboratories. The retention of patent rights by the DOE laboratory contractors will provide new opportunities to stimulate industrial interest in the DOE laboratories. We believe the class waivers can be implemented effectivley without adverse impact on ongoing programs. This implementation will be an area of intense interest over the next few months.

Fourth, we will encourage the laboratories to continue to increase cooperative projects with industry. The laboratories have made good progress in this area, and I believe this will remain an important way to create new industry. Of particular interest will be exploring innovative funding arrangements involving federal and private research dollars.

Finally, we want to encourage the exchange of laboratory and industry scientists and researchers. This is one of the best ways we know of transferring laboratory knowledge and expertise to industry by getting industry into the laboratory and helping them solve technology problems. In addition to this, these visiting appointments are very effective in establishing and fostering government-industry partnerships.

The Department of Energy is proud of its long history of providing U.S. industry with important technology to meet our nation's current and future technology needs. The DOE and its laboratories have made excellent progress in making federally-developed technology available to industry, and we expect this progress to continue. The Department will continue to encourage technology transfer through a combination of sound policies and effective laboratory programs.

That concludes my prepared statement. I will be happy to answer your questions at this time.

Senator DOMENICI. Thank you very much, Doctor. With the Committee's permission, we will hear from Dr. Bloch, and then we'll inquire of both.

Dr. Bloch.

STATEMENT OF DR. ERICH BLOCH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. BLOCH. Thank you, Mr. Chairman. I appreciate the opportunity to testify on the subject of technology transfer, which is a real important subject. But, before I do that, I want to commend you, Mr. Chairman, Senator Bingaman and Congressman Lujan, for your support for science and technology in Congress in the past, and I hope that we can enjoy your support in the future as well.

I wanted to focus—while this conference focuses primarily on Federal lab technologies and the commercialization of that, I wanted to focus a little bit on another generator of knowledge, namely, the universities of the United States. They are an underutilized resource, also, as far as the transfer of technology is concerned.

The basic underpinnings of technology transfer are, first of all, an adequate support for basic research that generates new knowledge; second, the availability of trained people capable of performing research, and the subsequent translation of new knowledge into technology and into products that are viable in the global marketplace; third, communication, collaboration and cooperation among the people and institutions that generate the new knowledge on the one hand, and those that have a need for it on the other hand. People are still the best transfer mechanism for complex concepts, scientific knowledge, and engineering know-how. And, with your permission, I would like to address these three points in my testimony this morning.

First let me talk about the research base and economic competitiveness. The economic competitiveness and prosperity of our nation rest on the health of the research base. This dependence, which has always been strong, is increasing. It is increasing for a number of reasons.

More of our manufacturing sector depends increasingly on new materials, new tools, new processes, and new techniques, such as the use of computers, to control manufacturing processes and the design of products.

Second, new and sophisticated instrumentation which was at one time only available in research laboratories has found its place in manufacturing for the purpose of controlling material parameters and other aspects of the manufacturing process.

And third, what is true about the manufacturing sector is equally true about our service sector. It depends on new technology equally.

The employment of science and engineering Ph.D.s in all of industry is increasing. It's increasing from about 24 percent, in 1973, of all Ph.D.s employed in the United States, to 31 percent in 1985. All these trends are evident to our trading partners as well and we are, therefore, facing competition not only in the marketplace but in research as well. And especially Japan, if I might want to—

might focus on it—is changing its strategy from one of not pursuing basic research to one of pursuing more and more basic research themselves.

In both high and low technology products, success in global markets means creating and applying new knowledge—the result of research and innovation—faster than one's competitors. Effective and timely technology transfer is, therefore, a must.

Since the key to innovation and new product development is the generation of new knowledge and its transfer, a critical part of the explanation for our slipping performance must therefore be sought in the condition of the science and engineering base and the relationship of key performers in the process of research and development.

The recently released report on the health of universities by the White House Science Council panel chaired by David Packard and Allan Bromley views as urgent the problems besetting the university research community today. The panel notes that at a time when increasing demands are being made on our research universities, they are facing problems. The capital costs of research have been increasing, adding to the burden of the universities that already must contend with the challenge of modernizing facilities and replacing obsolete equipment.

Too few of our students are choosing science and engineering careers, and demographic trends indicate that the pool of college students from whom they will be drawn is shrinking. We are not doing enough to support interdisciplinary, problem-oriented research directed at broad national needs.

Recent funding trends show that as a fraction of GNP, Federal support for basic research in universities peaked in 1968 and has since declined by 25 percent, as measured in 1972 constant dollars, even though in absolute dollars it had a significant increase.

Senator DOMENICI. Is that all of research——

Dr. BLOCH. No, this is essentially that part of research which we are spending in universities.

Senator DOMENICI. Yes, but from what Federal sources? All of them?

Dr. BLOCH. From all Federal sources.

Senator DOMENICI. So whether it's NSF or the National Institutes of Health——

Dr. BLOCH. The DOD or DOE, what have you, it's all included. NIH properly is included.

Senator DOMENICI. Would you tell us again, what is the ratio of—in 1968 it was——

Dr. BLOCH. As a fraction of GNP, in 1960—since 1968, this has declined by 25 percent.

The message is clear. We must substantially increase our Nation's support for university basic research to address these areas of need. A failure to do so now will result in a continued erosion of our competitive position.

This administration has taken important steps to address the problem by increasing Federal support for basic research despite serious budgetary constraints. However, a sustained effort will be needed to provide the basic research results that will be the foundation for our long term economic competitiveness.

Let me just say that the 1987 budget for the National Science Foundation is a case in point, and Congress must pass that budget. Three primary issues must be addressed. We must support promising new research fields and promote them through multidisciplinary work.

Such research requires, even mandates, the participation of industry. Together, industry and universities can focus on fundamental research in areas of national importance. Their collaboration is an important element in the timely transfer of new knowledge to our industries. We must address the backlog of needs at universities for adequate research facilities and equipment.

The second major underpinning for technology transfer is the availability of adequate numbers of trained people, of high quality, working at the forefront of their disciplines. We clearly face some problems in this regard.

Science and engineering enrollment has not kept pace with our population increase. We can expect further declines as the number of 22-year-olds, as a percentage of our population, drops over the next decade, unless we succeed in attracting more of our young people to the study of science and engineering. This, in turn, requires that we develop a knowledge base in the sciences and mathematics among our precollege students. It's a little bit late when we do it in college.

We must also address the problem of the underrepresentation of women, minorities and the handicapped in the science and engineering fields. These groups represent an important and underutilized human resource.

Finally, it is important that we increase the production of Ph.D.s to meet the needs of industry and to fill faculty openings, particularly in critical areas like computer science and electrical engineering, as well as in the classical disciplines like mathematics.

Despite a steady increase in foreign degree holders, the number of Ph.D. candidates as a percentage of all science and engineering undergraduate degrees is declining, and has been declining for years.

Effective use of our human resources and of our basic research knowledge, and strong support for basic research, will produce the knowledge we need for innovation. But for innovation to take place and for productivity to increase, we must translate this knowledge into commercial application. This depends on cooperation among the supporters and performers of research—the universities, industry, the Federal and local governments, and the Federal laboratories.

Cultivating a climate which encourages cooperation in research is therefore important in encouraging innovation. One example is the Joint Research and Development Act which President Reagan signed into law in 1984. This clarification of the antitrust legislation encourages companies to cooperate on research.

Another is cooperation among Federal agencies on increasing support for university research instrumentation and making available sophisticated equipment in the national laboratories to university researchers and industrial researchers, like synchrotron light sources.

Yet another is the cooperative effort of Federal and State agencies and universities to develop electronic networks accessible to the university community like here in New Mexico, New York and Michigan, in the Southeast, and other parts of the country.

The National Science Foundation has instituted a number of programs and initiatives that depend on industry/university/government cooperation. The engineering centers—and I won't say much more about it, since it's a well-focused kind of a program that has been discussed many times.

A different type of center are the industry/university centers. Over the last decade, these centers have encouraged industry/university interaction on industrially relevant research topics and contributed to the knowledge base which supports industrial advancement. The National Science Foundation provides seed money for the centers, which are expected to become self-sustaining with industry and State funding within a 5-year time period. Today, seven of the existing 40 centers are self-sustaining, and total industry and State support exceeds $27 million. Now it's $3 or $4 million.

By the way, I should mention that the New Mexico Institute of Mining and Technology has such a center and is establishing such a center right now on "energetic materials."

Another area where the National Science Foundation is instrumental is in the small business grants. NSF developed this innovative research program and it became the model for the governmentwide effort legislated in the Small Business Innovation Development Act. The program provides an opportunity for small technology-intensive firms to conduct creative research. The seed money supplied by the Government for the initial phases of research is leveraged in later phases by private venture capital.

Even the Presidential Young Investigator Program, whose primary function is to attract our best minds to academic careers in science and engineering, reenforces technology transfer by establishing links with peers between universities and industries and by matching Federal dollars with industry contributions.

To provide a general sense of the value of such programs, let me point out that today NSF is leveraging about $250 million from industry on its $1,300 million budget. Let me focus on this for 1 more minute.

It's not the dollars only that are of importance, but it's the relationships that are being built up by essentially having a company put money into a university for a particular task and for a particular project. It links people together, it makes people—it forces people to talk to each other, and as I pointed out before, people are the best transfer agents that we have.

These activities, added to our support for engineering research, our focus on human resource problems, on undergraduate education, and on broadening the participation of underrepresented institutions in science and engineering, represents a broad-based effort within the mission of the Foundation that is directly relevant to the problem this hearing addresses.

Mr. Chairman, there are many steps between the creation of a new piece of knowledge and the introduction of a new product on the market. In my testimony I have tried to focus on some of the essential components of the process; namely, there must be adequate support for the basic research, for the facilities and equipment needed to generate the knowlege base for innovation.

Second, the human resources needed to create this knowledge must be available, trained, and its quality must be high.

Third, we must continually improve the climate for communication and cooperation among the people and institutions on whom the process of innovation depends. We cannot win the competition in the global markets if we do not cooperate among ourselves.

I will be happy to answer any questions. Thank you very much.

[The prepared statement of Dr. Bloch follows:]

ERICH BLOCH
DIRECTOR
NATIONAL SCIENCE FOUNDATION
TESTIMONY BEFORE THE
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
AND THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
SEPTEMBER 4, 1986
ALBUQUERQUE, NEW MEXICO

"TECHNOLOGY TRANSFER"

CHAIRMAN DOMENICI, MR. LUJAN, I APPRECIATE THIS OPPORTUNITY TO TESTIFY BEFORE YOUR COMMITTEES ON THE SUBJECT OF TECHNOLOGY TRANSFER.

THE BASIC UNDERPINNINGS OF TECHNOLOGY TRANSFER ARE:

- FIRST, ADEQUATE SUPPORT FOR BASIC RESEARCH THAT GENERATES NEW KNOWLEDGE;

- SECOND, THE AVAILABILITY OF TRAINED PEOPLE CAPABLE OF PERFORMING RESEARCH, AND THE SUBSEQUENT TRANSLATION OF NEW KNOWLEDGE INTO TECHNOLOGY AND INTO PRODUCTS THAT ARE VIABLE IN THE GLOBAL MARKETPLACE;

O THIRD, COMMUNICATION, COLLABORATION, AND COOPERATION AMONG THE PEOPLE AND INSTITUTIONS THAT GENERATE THE NEW KNOWLEDGE ON THE ONE HAND, AND THOSE THAT HAVE A NEED FOR IT ON THE OTHER HAND. PEOPLE ARE STILL THE BEST TRANSFER MECHANISM FOR COMPLEX CONCEPTS, SCIENTIFIC KNOWLEDGE, AND ENGINEERING KNOW-HOW.

I WOULD LIKE TO ADDRESS THESE THREE POINTS IN MY TESTIMONY TODAY.

RESEARCH BASE AND ECONOMIC COMPETITIVENESS

THE ECONOMIC COMPETITIVENESS AND PROSPERITY OF OUR NATION REST ON THE HEALTH OF THE RESEARCH BASE. THIS DEPENDENCE, WHICH HAS ALWAYS BEEN STRONG, IS INCREASING:

O MORE OF OUR MANUFACTURING SECTOR DEPENDS INCREASINGLY ON NEW MATERIALS, NEW TOOLS, NEW PROCESSES, AND NEW TECHNIQUES, SUCH AS THE USE OF COMPUTERS, TO CONTROL MANUFACTURING PROCESSES AND THE DESIGN OF PRODUCTS.

NEW AND SOPHISTICATED INSTRUMENTATION WHICH WAS AT ONE TIME ONLY AVAILABLE IN RESEARCH LABORATORIES HAS FOUND ITS PLACE IN MANUFACTURING FOR THE PURPOSE OF

CONTROLLING MATERIAL PARAMETERS AND OTHER ASPECTS OF THE MANUFACTURING PROCESS.

- THE EMPLOYMENT OF SCIENCE AND ENGINEERING PH.D.'S IN INDUSTRY IS INCREASING. IN FACT, THE PERCENT INCREASE IN PHD INDUSTRIAL EMPLOYMENT IS OUTSTRIPPING THEIR PERCENT INCREASE IN ACADEMIC EMPLOYMENT.

WHAT IS TRUE OF US AND OUR INDUSTRIES APPLIES EQUALLY TO OUR TRADING PARTNERS. WE ARE, THEREFORE, FACING COMPETITION NOT ONLY IN THE MARKETPLACE, BUT IN RESEARCH AS WELL.

SINCE WORLD WAR II, NEW TECHNOLOGY HAS BEEN RESPONSIBLE FOR NEARLY HALF OF ALL PRODUCTIVITY GAINS, MORE THAN CAPITAL INVESTMENT, BETTER EDUCATION, BETTER RESOURCE ALLOCATION, OR ECONOMIES OF SCALE. AND HIGH PRODUCTIVITY, IN TURN, IS THE BASIS OF COMPETITIVENESS.

IT HAS, THEREFORE, BEEN A SOURCE OF CONCERN IN THE U.S. THAT UP TO 1983 OUR PRODUCTIVITY RECORD WAS SUBSTANTIALLY WORSE THAT THAT OF OUR MAJOR COMPETITORS. THEY DID NINE TIMES BETTER THAN WE DID DURING THIS PERIOD. WE HAVE BEEN GLAD TO NOTE, HOWEVER, THAT OUR PERFORMANCE WITH RESPECT TO PRODUCTIVITY HAS IMPROVED SUBSTANTIALLY IN THE PAST COUPLE OF YEARS.

IN BOTH HIGH AND LOW TECHNOLOGY PRODUCTS, SUCCESS IN GLOBAL

MARKETS MEANS CREATING AND APPLYING NEW KNOWLEDGE -- THE RESULT OF RESEARCH AND INNOVATION -- FASTER THAN ONE'S COMPETITORS. THE TIME FROM RESEARCH TO MARKET EXPLOITATION IS SHRINKING. EFFECTIVE -- AND TIMELY -- TECHNOLOGY TRANSFER IS, THEREFORE, A MUST.

WE ARE VULNERABLE IN BOTH OUR HIGH TECH AND OUR MORE TRADITIONAL INDUSTRIES IN PART BECAUSE WE HAVE BEEN SLOW TO APPLY THIS LESSON TO MANUFACTURING RESEARCH. IT IS A MULTIDISCIPLINARY ACTIVITY WORTHY OF ACADEMIC ATTENTION AND SERIOUS PRIVATE SECTOR AND GOVERNMENT INVESTMENT. WE ARE ONLY NOW LAYING THE SCIENTIFIC BASE FOR IT.

TOO OFTEN WE HAVE TRIED TO REPLICATE THE ADVANTAGE ENJOYED BY SOME OF OUR COMPETITORS IN THEIR ACCESS TO LOW COST LABOR BY SHIFTING PRODUCTION OVERSEAS. THE ULTIMATE RESULT HAS BEEN TO SLOW THE APPLICATION OF NEW PROCESS TECHNOLOGY, FURTHER AGGRAVATING OUR TRADE POSITION.

THESE ARE AMONG THE REASONS WHY OUR TRADE BALANCE HAS DETERIORATED SO SIGNIFICANTLY IN THE PAST FEW YEARS. WHILE OUR WORST RECORD HAS BEEN IN THE OLDER INDUSTRIAL AREAS, WE ARE SLIPPING IN THE HIGH TECHNOLOGY FIELDS AS WELL.

SINCE THE KEY TO INNOVATION AND NEW PRODUCT DEVELOPMENT IS THE GENERATION OF NEW KNOWLEDGE AND ITS TRANSFER, A CRITICAL PART OF

THE EXPLANATION FOR OUR SLIPPING PERFORMANCE MUST, THEREFORE, BE SOUGHT IN THE CONDITION OF THE SCIENCE AND ENGINEERING BASE AND THE RELATIONSHIP OF KEY PERFORMERS IN THE PROCESS OF RESEARCH AND DEVELOPMENT.

THE RECENTLY RELEASED REPORT ON THE HEALTH OF UNIVERSITIES BY THE WHITE HOUSE SCIENCE COUNCIL PANEL CHAIRED BY DAVID PACKARD AND ALLAN BROMLEY VIEWS AS URGENT THE PROBLEMS BESETTING UNIVERSITY RESEARCH COMMUNITY TODAY.

THE PANEL NOTES THAT AT A TIME WHEN INCREASING DEMANDS ARE BEING MADE ON OUR RESEARCH UNIVERSITIES, THEY ARE FACED WITH A DETERIORATING RESEARCH BASE.

- THE CAPITAL COSTS OF RESEARCH HAVE BEEN INCREASING, ADDING TO THE BURDEN OF THE UNIVERSITIES THAT ALREADY MUST CONTEND WITH THE CHALLENGE OF MODERNIZING FACILITIES AND REPLACING OBSOLETE EQUIPMENT.

- TOO FEW OF OUR STUDENTS ARE CHOOSING SCIENCE AND ENGINEERING CAREERS. AND DEMOGRAPHIC TRENDS INDICATE THAT THE POOL OF COLLEGE STUDENTS FROM WHOM THEY WILL BE DRAWN IS SHRINKING;

- WE ARE NOT DOING ENOUGH TO SUPPORT INTERDISCIPLINARY, PROBLEM ORIENTED RESEARCH DIRECTED AT BROAD NATIONAL

NEEDS.

RECENT FUNDING TRENDS SHOW THAT AS A FRACTION OF GNP, FEDERAL SUPPORT FOR BASIC RESEARCH IN UNIVERSITIES PEAKED IN 1968 AND HAS SINCE DECLINED BY 25%, AS MEASURED IN 1972 CONSTANT DOLLARS.

THE MESSAGE IS CLEAR. WE MUST SUBSTANTIALLY INCREASE OUR NATION'S SUPPORT FOR UNIVERSITY BASIC RESEARCH TO ADDRESS THESE AREAS OF NEED. A FAILURE TO DO SO NOW WILL RESULT IN A CONTINUED EROSION OF OUR COMPETITIVE POSITION.

THIS ADMINISTRATION HAS TAKEN IMPORTANT STEPS TO ADDRESS THE PROBLEM BY INCREASING FEDERAL SUPPORT FOR BASIC RESEARCH DESPITE SERIOUS BUDGETARY CONSTRAINTS. HOWEVER, A SUSTAINED EFFORT WILL BE NEEDED TO PROVIDE THE BASIC RESEARCH RESULTS THAT WILL BE THE FOUNDATION FOR OUR LONG-TERM ECONOMIC COMPETITIVENESS.
THREE PRIMARY ISSUES MUST BE ADDRESSED:

- WE MUST SUPPORT PROMISING NEW RESEARCH FIELDS, AND PROMOTE THEM THROUGH MULTIDISCIPLINARY WORK.

- SUCH RESEARCH NEEDS THE PARTICIPATION OF INDUSTRY. TOGETHER, INDUSTRY AND UNIVERSITIES CAN FOCUS ON FUNDAMENTAL RESEARCH IN AREAS OF NATIONAL IMPORTANCE. THEIR COLLABORATION IS AN IMPORTANT ELEMENT IN THE TIMELY TRANSFER OF NEW KNOWLEDGE TO OUR INDUSTRIES.

- WE MUST ADDRESS THE BACKLOG OF NEEDS AT UNIVERSITIES FOR ADEQUATE RESEARCH FACILITIES AND EQUIPMENT.

AS I WILL INDICATE LATER IN MY TESTAMONY, WE ARE WORKING WITH OTHER FEDERAL AGENCIES, THE STATES, AND THE PRIVATE SECTOR TO ADDRESS THESE NEEDS.

HUMAN RESOURCES

THE SECOND MAJOR UNDERPINNING FOR TECHNOLOGY TRANSFER IS THE AVAILABILITY OF ADEQUATE NUMBERS OF TRAINED PEOPLE OF HIGH QUALITY WORKING AT THE FOREFRONT OF THEIR DISCIPLINES. WE CLEARLY FACE SOME PROBLEMS IN THIS REGARD:

- SCIENCE AND ENGINEERING ENROLLMENT HAS NOT KEPT PACE WITH OUR POPULATION INCREASE;
- WE CAN EXPECT FURTHER DECLINES AS THE NUMBER OF 22 YEAR OLDS, AS A PERCENTAGE OF OUR POPULATION, DROPS OVER THE NEXT DECADE, UNLESS WE SUCCEED IN ATTRACTING MORE OF OUR YOUNG PEOPLE TO THE STUDY OF SCIENCE AND ENGINEERING.

- THIS IN TURN REQUIRES THAT WE DEVELOP A KNOWLEDGE BASE IN THE SCIENCES AND MATHEMATICS AMONG OUR PRECOLLEGE STUDENTS;

- WE MUST ALSO ADDRESS THE PROBLEM OF THE UNDERREPRESENTATION OF WOMEN, MINORITIES, AND THE HANDICAPPED IN THE SCIENCE AND ENGINEERING FIELDS. THESE GROUPS REPRESENT AN IMPORTANT AND UNDERUTILIZED HUMAN RESOURCE.

- FINALLY, IT IS IMPORTANT THAT WE INCREASE THE PRODUCTION OF PH.D.'S TO MEET THE NEEDS OF INDUSTRY AND TO FILL FACULTY OPENINGS, PARTICULARLY IN CRITICAL AREAS LIKE COMPUTER SCIENCE AND ELECTRICAL ENGINEERING.

  DESPITE A STEADY INCREASE IN FOREIGN DEGREE HOLDERS,THE NUMBER OF PH.D. CANDIDATES, AS A PERCENTAGE OF ALL SCIENCE AND ENGINEERING UNDERGRADUATE DEGREES, IS DECLINING, AND WE CANNOT AND SHOULD NOT RELY ON FOREIGN SOURCES TO MEET OUR NEEDS.

INNOVATION

EFFECTIVE USE OF OUR HUMAN RESOURCES AND STRONG SUPPORT FOR BASIC RESEARCH WILL PRODUCE THE KNOWLEDGE WE NEED FOR INNOVATION. BUT

FOR INNOVATION TO TAKE PLACE AND FOR PRODUCTIVITY TO INCREASE WE MUST TRANSLATE THIS KNOWLEDGE INTO COMMERCIAL APPLICATION. THIS DEPENDS ON COOPERATION AMONG THE SUPPORTERS AND PERFORMERS OF RESEARCH: UNIVERSITIES, INDUSTRY, AND THE FEDERAL AND LOCAL GOVERNMENTS.

- THE CULTIVATION OF A NATIONAL POLICY CLIMATE WHICH ENCOURAGES COOPERATION IN RESEARCH IS THEREFORE IMPORTANT IN ENCOURAGING INNOVATION:
  - ONE EXAMPLE IS THE JOINT RESEARCH AND DEVELOPMENT ACT WHICH PRESIDENT REAGAN SIGNED INTO LAW IN 1984. THIS CLARIFICATION OF THE ANTI-TRUST LEGISLATION ENCOURAGES COMPANIES TO COOPERATE ON RESEARCH;
  - ANOTHER IS COOPERATION AMONG FEDERAL AGENCIES ON INCREASING SUPPORT FOR UNIVERSITY RESEARCH INSTRUMENTATION;
  - YET ANOTHER IS THE COOPERATIVE EFFORT OF FEDERAL AND STATE AGENCIES AND UNIVERSITIES TO DEVELOP ELECTRONIC NETWORKS ACCESSIBLE TO THE UNIVERSITY COMMUNITY HERE IN NEW MEXICO, NEW YORK, MICHIGAN,

THE SOUTHEAST, AND OTHER PARTS OF THE COUNTRY.

THE NATIONAL SCIENCE FOUNDATION HAS INSTITUTED A NUMBER OF PROGRAMS AND INITIATIVES THAT DEPEND ON INDUSTRY/UNIVERSITY/GOVERNMENT COOPERATION:

- THE ENGINEERING RESEARCH CENTERS: IN THE LAST TWO YEARS, THE NATIONAL SCIENCE FOUNDATION HAS MADE ELEVEN AWARDS FOR SUCH CENTERS, EACH OF WHICH FOCUSES ON AN IMPORTANT AREAS OF ENGINEERING. EACH CENTER BRINGS TOGETHER RESEARCHERS FROM DIFFERENT DISCIPLINES AND FROM ACADEMIA AND INDUSTRY AND IS EXPECTED TO IMPROVE ENGINEERING EDUCATION BY INVOLVING GRADUATE AND UNDERGRADUATE STUDENTS IN SOLVING COMPLEX PROBLEMS AT THE FOREFRONT OF RESEARCH.

  THE PROBLEMS THE ERC'S HAVE CHOSEN -- IN SUCH FIELDS AS:

  - TELECOMMUNICATIONS
  - BIOTECHNOLOGY
  - ROBOTIC SYSTEMS
  - ADVANCED COMBUSTION
  - SEMICONDUCTOR MICROELECTRONICS
  - LARGE STRUCTURAL SYSTEMS, AND
  - NET SHAPE MANUFACTURING

ARE INTELLECTUALLY EXCITING AND POTENTIALLY HAVE GREAT ECONOMIC IMPORTANCE.

THESE CENTERS SHOULD BE SUCCESSFUL BECAUSE THEY MEET A REAL NEED WITH A TRULY INNOVATIVE APPROACH. THEY BRING TOGETHER VARIOUS SCIENCE AND ENGINEERING DISCIPLINES TO ADDRESS IMPORTANT PROBLEMS THAT HAVE PRACTICAL IMPLICATIONS. THEY ENCOURAGE CHANGE IN THE UNIVERSITIES, REDUCING THEIR ORGANIZATIONAL DEPENDENCE ON A DISCIPLINARY STRUCTURE THAT IS NO LONGER IDEAL FOR MANY PURPOSES.

THE RELATIONSHIP THESE CENTERS ENCOURAGE BETWEEN INDUSTRY AND UNIVERSITIES WORKS TO THE BENEFIT OF BOTH. ACADEMIC RESEARCHERS GAIN THE PERSPECTIVE OF WORKING ON PROBLEMS OF ECONOMIC CONSEQUENCE. AND INDUSTRY GAINS ACCESS TO THE MOST CREATIVE MINDS AMONG THE FACULTY AND GRADUATE STUDENTS.

- INDUSTRY/UNIVERSITY CENTERS: OVER THE LAST DECADE, THESE CENTERS HAVE ENCOURAGED INDUSTRY/UNIVERSITY INTERACTION ON INDUSTRIALLY RELEVANT GRADUATE SCIENCE AND ENGINEERING RESEARCH TOPICS WHILE CONTRIBUTING TO THE KNOWLEDGE BASE WHICH SUPPORTS INDUSTRIAL ADVANCEMENT.

THE NATIONAL SCIENCE FOUNDATION PROVIDES SEED MONEY FOR THE CENTERS, WHICH ARE EXPECTED TO BECOME SELF-SUSTAINING WITH INDUSTRY AND STATE FUNDING WITHIN A 5 YEAR PERIOD OF TIME. TODAY, 7 OF THE EXISTING 40 CENTERS ARE SELF SUSTAINING AND TOTAL INDUSTRIAL AND STATE SUPPORT EXCEEDS $27 MILLION.

- SMALL BUSINESS GRANTS: THE NSF-DEVELOPED SMALL BUSINESS INNOVATION RESEARCH PROGRAM BECAME THE MODEL FOR THE GOVERNMENT-WIDE EFFORT LEGISLATED IN THE SMALL BUSINESS INNOVATION DEVELOPMENT ACT. THE PROGRAM PROVIDES AN OPPORTUNITY FOR SMALL SCIENCE AND TECHNOLOGY INTENSIVE FIRMS TO CONDUCT CREATIVE RESEARCH. THE SEED MONEY SUPPLIED BY THE GOVERNMENT FOR THE INITIAL PHASES OF RESEARCH IS LEVERAGED IN LATER PHASES BY PRIVATE VENTURE CAPITAL.

- PRESIDENTIAL YOUNG INVESTIGATOR AWARDS: EVEN THE PYI PROGRAM, WHOSE PRIMARY FUNCTION IS TO ATTRACT OUR BEST MINDS TO ACADEMIC CAREERS IN SCIENCE AND ENGINEERING, REINFORCES TECHNOLOGY TRANSFER BY ESTABLISHING LINKS BETWEEN PEERS IN UNIVERSITIES AND INDUSTRIES AND BY MATCHING FEDERAL DOLLARS WITH INDUSTRY CONTRIBUTIONS.

TO PROVIDE A GENERAL SENSE OF THE VALUE OF SUCH PROGRAMS, LET ME POINT OUT THAT TODAY NSF IS LEVERAGING $250 MILLION FROM INDUSTRY, STATES, AND UNIVERSITIES ON ITS $1,300 MILLION. THESE ACTIVITIES, ADDED TO OUR SUPPORT FOR ENGINEERING RESEARCH, OUR FOCUS ON HUMAN RESOURCE PROBLEMS, ON UNDERGRADUATE EDUCATION, AND ON BROADENING THE PARTICIPATION OF UNDERREPRESENTED INSTITUTIONS IN SCIENCE AND ENGINEERING, REPRESENTS A BROAD-BASED EFFORT WITHIN THE MISSION OF THE FOUNDATION THAT IS DIRECTLY RELEVANT TO THE PROBLEM THIS HEARING ADDRESSES.

CONCLUSION

MR. CHAIRMAN, THERE ARE MANY STEPS BETWEEN THE CREATION OF A NEW PIECE OF KNOWLEDGE AND THE INTRODUCTION OF A NEW PRODUCT ON THE MARKET.

IN MY TESTIMONY I HAVE TRIED TO FOCUS ON SOME OF THE ESSENTIAL COMPONENTS OF THE PROCESS:

- THERE MUST BE ADEQUATE SUPPORT FOR THE BASIC RESEARCH, FACILITIES, AND EQUIPMENT NEEDED TO GENERATE THE KNOWLEDGE BASE FOR INNOVATION;

- THE HUMAN RESOURCES NEEDED TO CREATE THIS KNOWLEDGE MUST BE AVAILABLE;

- WE MUST CONTINTUALLY IMPROVE THE CLIMATE FOR COMMUNICATION AND COOPERATION AMONG THE PEOPLE AND INSTITUTIONS ON WHOM THE PROCESS OF INNOVATION DEPENDS. WE CANNOT WIN THE COMPETITION IN THE GLOBAL MARKETS IF WE DO NOT COOPERATE AMONG OURSELVES.

I WILL BE HAPPY TO ANSWER ANY QUESTIONS YOU HAVE.

Senator DOMENICI. Thank you very much.

Senator Bingaman, would you like to inquire first?

Senator BINGAMAN. OK. Thank you.

Let me just ask Dr. Decker first of all if the statistic that Congressman Lujan cited, which I think is one that I have also heard, which is that the Government owns 28,000 patents, only 5 percent of which are licensed to the private sector.

In your view, is that a sign of a very serious problem with regard to our technology transfer policy?

Dr. DECKER. Yes, I think it is. I believe that the steps that Congress has taken with the Bayh-Dole Act to transfer patent rights to the Government contractors is a major step forward, because I think it's going to be much easier to transfer technology when the patents are, in fact, in the hands of the contractor rather than the Government.

Senator BINGAMAN. As I understand Mr. Welber's testimony, which is going to be made here shortly, he suggests that the Bayh-Dole Act needs to be amended to include the nuclear weapons laboratories so that they could take title to inventions made at those laboratories and play a more direct role in licensing those.

Do you agree with that suggestion?

Dr. DECKER. No, in the following sense. I think that the weapons laboratories will get rights to inventions arising out of a number of areas of research that they're engaged in. However, there are some exceptions—defense programs, funded research and development, the Navy nuclear propulsion work, and also some things in uranium enrichment. There we have a couple of concerns, one of which is the national security concern.

Let me just take the example of the nuclear weapons development activities. Clearly we have to be concerned about nuclear proliferation and we want to be careful to control the technologies in an appropriate way.

The second concern that we have was actually mentioned by Ray Romatowski in his opening remarks, and that is that there must be a free flow of information among all the contractors who are involved in the nuclear weapons development and production activities. We would not like to see information being withheld because it may have commercial potential. That would inhibit, I think, the effectiveness of our weapons development program.

But I should point out that if there are spinoff technologies from nuclear weapons work or any of these other programs that are exceptions that I mentioned, the contractor can certainly apply for a waiver on a case-by-case basis.

Senator BINGAMAN. Let me just see if I can clarify that.

My understanding is that last year there were 13 patents filed by DOE for the work done at Sandia Laboratories. It strikes me that—as I understand it, Sandia goes through patent attorneys, DOE patent attorneys—is not able to file directly. That's part of the problem.

It seems to me that 13 is a very low rate, considering the extent of the research effort and the quality of the research effort going on at Sandia Laboratories. Is there a bottleneck there which needs to be addressed some way or other? I mean, the suggestion that

DOE should continue to screen everything and go through it doesn't seem to me to solve the problem.

Dr. DECKER. Yes, I think there is a bottleneck that needs to be addressed there. I don't pretend to be an expert on that particular patent situation.

If I remember correctly, there was actually something in the Sandia contract with the Department that caused them some difficulties in applying for patents. That's an item that the Department is addressing with Sandia and we hope to clear up.

Senator BINGAMAN. You say the Department of Energy is addressing this with Sandia in order to expedite this process?

Dr. DECKER. Yes, we are.

Senator BINGAMAN. I also understand that not only are a very few getting through, there is also a substantial lag time. And I think Dr. Bloch correctly pointed out that the ability to get any commercial benefit out of new developments is very time sensitive. Obviously, to the extent that we have long delays involved, the chance of getting any meaningful spinoff from these research activities is reduced. Do you agree with that?

Dr. DECKER. I certainly agree with that. In fact, the General Counsel's office is looking at trying to streamline the Department's patent process.

Senator BINGAMAN. Let me just get one more shot at the initial question about whether you think the DOE laboratories should be able to play a more direct role in licensing. I guess you're saying that they should not be able to play a more direct role because of certain areas of research activity that they're involved in, or would you agree that some kind of direct licensing role is appropriate in some areas of research but not appropriate in others?

Could you be more specific on that?

Dr. DECKER. It's the latter. There is certainly a broad range of research activities that the Department sponsors in its laboratories, where we expect to grant waivers to the laboratories, and then they can go ahead and license the patents directly. There are these exceptions, though, that I mentioned.

Senator BINGAMAN. But there have been no waivers granted to date?

Dr. DECKER. No. The reason for that is that, as I understand it, the 1984 amendment to the Bayh-Dole Act required the Department of Commerce to promulgate regulations in this area, and those regulations just came out, I think in the last month or so. And so obviously we had to wait and make our patent policy agree with the Department of Commerce's regulations. And now that that's behind us, I would expect that our patent policy and waivers should be in place before the end of the year.

Senator BINGAMAN. Let me ask about a particular provision that Congressman Solomon, or Representative Solomon, put into the Defense Authorization Act this year. As I understand this Solomon amendment, it has the purported goal of protecting sensitive technical information which is developed in the nuclear weapons program, even though the information in some cases is unclassified. As I understand it, it also sets up a whole host of hurdles that the Secretary of Energy needs to go through before he can assign to a contractor any property rights to an invention.

Are you familiar with the Solomon amendment as it exists in this proposed Department of Defense authorization bill?

Dr. **Decker**. No, sir; I am not. I just heard mention of it last night by somebody, but I'm not familiar with it.

Senator **Bingaman**. If possible, perhaps when we go back into session next week, we will start the conference with the House and Senate on that. If there's a way we could get your reaction to it in time for me to make that point of view known during the conference, that would be very helpful.

Dr. **Decker**. We would be glad to provide that to you.

[The information follows:]

The DOE fully supports the intent of the Solomon Amendment to provide for the continued protection of sensitive technologies and data. The intent of this amendment is to clarify the national security interest at government-owned, contractor-operated laboratories in the context of legislation and Administration patent policy initiatives to foster domestic technological advances. The Department has an effective and positive patent policy consistent with legislation that includes a provision for waiver requests from DOE contractors.

Senator **Bingaman**. Let me ask Dr. Bloch, if I could, just—I guess one of the concerns that you addressed partly, and that greatly concerns me, is the lack of adequate numbers of students going into math and science overall in our university system. And as you point out, we really have to look at prior to the university in order to identify the right people.

I guess I would be interested, first of all, in what should we be doing to address that—What should we, the Federal Government, be doing to address the problem of adequate numbers of students going into math and science at prior—at the levels prior to university—and second, do we have the same problem of—as we are getting fewer and fewer U.S. students as a percent going into these areas, do we have a real problem in the number of good quality people going into faculties in our universities in the math and science field?

I've heard people say that there's a crisis there with regard to, in the coming years, not having adequate faculty because of so many being hired away by the private sector, so many just not coming through the pipeline. Could you comment on that as well?

Dr. **Bloch**. Yeah. Let me take your second question first and talk about Ph.D.'s and faculties. As I mentioned in my testimony, the rate of Ph.D.'s is decreasing on us, and that should be a concern, especially since now industry depends to a greater extent on Ph.D.'s than it ever did before, and also we have right now a large number of faculty openings.

The other concern that we have is if you look at—it has been said many times there's a greying of the faculty going on. People that started right after the war in 1950, 1955, are all reaching the end of their careers and there will be a great need to fill these positions.

I don't know. It has been said it's a crisis. I don't know if I would give it that. Not everything is a crisis. And I think one wants to be very careful what one calls a crisis. I wouldn't call it a crisis, but I would call it a great concern. We need to attract more people to the Ph.D. track, No. 1, and more people into faculty positions.

Now, I think it is only one reason why that lack of people going into Ph.D. exists, being the differential between industry salaries and faculty salaries. That's one reason.

I think there is another reason. The other reason essentially is that our university environments are not up to snuff in instrumentation, in facilities, and so forth. Today you can do better research in terms of available facilities in industry and in the national laboratories than you can do in our universities, and we've got to rectify that situation. It's the whole environment; it's the whole ambiance in a university that needs some rectification, not just the salary aspect, and I don't want to diminish that aspect at all. But I'm saying that's not good enough.

So that's one thing. The Presidential Young Investigator Program is exactly aiming at that, trying to give somebody a headstart, a young individual a headstart in his research in a university environment, and keeping him there for the next 5 years. That's the intent in it. And we need more programs of that sort.

For instance, in the 1988 budget, we are contemplating increasing our graduate fellowship program. And that is of extreme importance, so that we can attract more people, support more people for the Ph.D. track.

Now to come to your other question of what to do about the precollege area. I think in the precollege area we have to rebuild the system that existed at one time, and that starts with teachers, having adequately trained teachers available, having adequately trained materials for teaching available in the sciences and in mathematics. And we have started in that. Over the last 3 years we are spending a sizable amount of our dollars in precollege education, and we focused on precollege education for exactly that reason, that we think there is a real need there, especially in the sciences and mathematics.

Senator BINGAMAN. Thank you very much.

Thank you, Mr. Chairman.

Senator DOMENICI. I'm going to yield to the Congressman, but let me just say on that last point, Senator Bingaman, it's really interesting to see what's happened. The National Science Foundation was intimately involved in the last aspect described by Dr. Bloch; that is, innovative programs that address the issue of junior high and high school math excitement, getting more people involved, teacher training centers and the kinds of things we had post-Sputnik. It had kind of disappeared. They retooled it and got it ready. In a general sense, the President, reluctantly but eventually, started putting it in the budget at a pretty high level. Both bodies, the House and Senate, in their broad votes on the budget, have increased the funding rather significantly.

But what's happened, last year, this year, and what he's fearful of in 1988, is that then that pile of money gets assigned to a subcommittee of appropriations along with some other areas—you can imagine the competition—housing, NASA, veterans, all in the same pot. The net effect has been we're talking a good game in the Congress in the first round, and we're coming out on the short end in the final round when we rob from that program to pay for some of the others. No complaints yet. We'll see what happens. But the House subcommittee did that specifically with reference to NSF this year. Part of that's got to come out of the kind of program you have just inquired of.

In the U.S. Senate the Committee on Appropriations did exactly the same thing. We thought we voted for a substantial increase in science and math education. I think you voted for it. Four hundred million dollars is my recollection. Everybody touted it as an investment in the future. If you look at the appropriation bill, it's frozen at this level and the $400 million has been spent for something else within the array of programs that I just described.

They're all good programs. Some of that money went to general education; some of it went to the National Institutes of Health. In fact, almost all of it, almost all that 400 went to increase the National Institutes of Health. They went up some $980 million in outlays, just that program, while the one you're addressing is frozen at this year's level. So I think we have some work cut out for us, too. Their programs have been increasing. I think this year an 18-percent increase in NSF. I don't believe there's a chance it'll come out of Congress at that level, but I think that's kind of the circle that he finds himself in.

Congressman Lujan.

Mr. LUJAN. Thank you very much, Mr. Chairman.

Dr. Decker, let me just say that our committees worked very well—particularly I'm more familiar with Los Alamos and Sandia, the efforts on technology transfer. Glenn and Bob Stromberg over here at Sandia and Gene Stark, when he was there at Los Alamos, and now I can tell you, of course, that we all keep looking for ways to do it better.

But I'd like to follow up a little bit on what Senator Bingaman was talking about, and that is more and more of the decision being made at the contractor level, at the laboratory level, as to what to license and what to patent.

It's my understanding that it's pretty much at the discretion of the contract what materials are classified, for example. Is that correct, that——

Dr. DECKER. Yes; I believe that's correct.

Mr. LUJAN. And if we can trust the laboratories to see what material is sensitive and which is not, it seems to me that it would just be a little easier for us to open up that decisionmaking process as to the patenting and licensing out down to the laboratories, what are not quite as sensitive, it would seem to me, as the classification. It's a comment that I would make and something we should look into. If you would care to make some comments about it.

Dr. DECKER. I certainly think the trend to get more and more decisions at the contractor level is right. Some of the issues that we have to deal with, in areas like nuclear proliferation, are such that I think it's reasonable that perhaps some of that get one more look at the headquarters level by people who are perhaps looking at things in a little broader perspective.

Mr. LUJAN. I've always felt that all the research that we do in the Federal Government—again, with the exception of sensitive military stuff—should end up in the private sector because that's how you and I as individuals are going to benefit from those $60 billion that we spend on research.

I tell you that because, you know, of the 28,000 or so patents that they tell us that you have, and 5 percent only being licensed, I was going to ask you—you know, if we really went all out with it and removed constraints that we have, it certainly would seem to me like 5 percent could very easily be exceeded. Of course, my hope—I don't know whether we can say 100 percent, but maybe 97 percent or something like that, except the very, very sensitive stuff. But, you know, that's something I'm sure we all work on.

Let me ask you a question——

Senator **Domenici**. Manny, would you yield on that?

Mr. **Lujan**. Yes.

Senator **Domenici**. I wonder—perhaps Dr. Decker is not the witness, but maybe somebody that follows. Doesn't that issue that was raised by the Congressman, 28,000 patented and 5 percent licensed, doesn't that give somebody an idea that, while there's not so much wrong with the patent part, there's something wrong with the licensing part. It would seem to me that we can't just keep saying patent more if we already got 28,000. What seems to me, from the little bit I've talked to, entrepreneurs and businessmen and Congressmen, the licensing modus operandi is not calculated to give the risk taker the benefit of the risk and he goes to look somewhere else.

It appears to me that that's the heart of the problem. Patents are patented and frequently never used because somebody had a great idea but nobody needs it. But in this case the ratio is inordinately high and something has got to be wrong with the second level. I don't know what that is. But it just seems to me, Congressman, that something is wrong there. The Government owns it, but nobody wants to use it.

Do either of you have any thoughts on that? And excuse me for interrupting.

Dr. **Decker**. I'm not sure I can add a whole lot to that. I mean, I think that those 28,000 patents and the 5 percent number have built up at a time when the Government—all patents did go to the Government directly. The Government, at least in some cases, has been very reluctant to provide exclusive licenses and that often is a difficulty to overcome——

Mr. **Lujan**. A difficulty to let go of the baby? Do you think maybe that's—You know, "I invented it, it's mine, and I don't want to——"

Dr. **Decker**. Not having been directly involved in patent licensing, I'm not sure what goes through people's minds. I have a feeling that there was a real concern over fairness, that somehow, if you gave someone an exclusive license to a Government patent, that somehow you weren't being fair, that you needed to leave it open, so that any companies could license a particular patent.

Mr. **Lujan**. Mr. Bloch, one of the interesting follow-ups you say—you know, we had been going down in productivity; in the last couple of years we have come up. Why?

Mr. **Bloch**. Well, I think—By the way, we shouldn't be satisfied with that improvement. We have a long way to go, as you know very well. But it's a good indicator.

I think there has been, over the last 2 to 4 years, there has been more of a focus by industry on productivity. There has been more of a focus by industry on quality, for instance. I think there's been more of a focus on costs. So I think the whole climate that industry is facing today forces focus on these particular problems. So I think you're seeing it as a reaction to the present situation, and I think it's a very welcome reaction. We have a long way to go.

Mr. LUJAN. Let me ask you, does the—Do we have, through the National Science Foundation, something that, you know, has been occurring to me, a crossing—encourage a crossing across disciplines. For example—Oh, I give briefings for Sandia and Los Alamos every once in a while, you know, that they went to NIH with this nuclear technology that they had that could be used to analyze some disease. Yesterday, the folks from McDonnell-Douglas were in my office and they were talking about a nozzle that they were trying to check out and they found they could use a medical CAT scanner that could tell them exactly what the weak points in the nozzle were and eventually put it in a trailer, and now they take it all over and test their stuff that way.

Do we have any kind of a program through the National Science Foundation—and, as a matter of fact, through DOE, I suppose—to try to take from one field into the other and use those applications?

Dr. BLOCH. Yes; we have many programs that address that particular area. There's not one that is labeled cross-disciplinary research or something like that. But there are many programs that are essentially focusing on that. The engineering research centers are programs of that sort. We are not just trying to foster interdisciplinary work in engineering but interdisciplinary work between science and engineering.

For instance, last year we looked at the first six centers that were established. It was kind of interesting that 25 percent of the participating faculty, or participating principal investigators, came out of the sciences, didn't come out of engineering. That's how it should be. OK. If you think of biotechnology, what is it? Is biotechnology chemistry or is it biology or is it chemical engineering or what? Well, the answer is it's neither. But it encompasses many of all of these disciplines. So we are focusing on that. We are focusing on it through computational sciences and engineering programs which we are fostering in all directives of the Foundation.

There is a new approach to life, a new approach to research life, namely, computation and modeling and simulation and so forth, and that requires an interdisciplinary kind of a team. This whole area of trying to link industry in with universities at a very fairly detailed level, like in the centers I discussed, the industry/university centers I discussed, I think are linking interdisciplinary kind of work together.

So in many of the programs, we are focusing on that. We are trying to break down the walls that have been established and have grown up with interdisciplines, because that's very important these days. Much of the emerging technologies is interdisciplinary kind of work.

Mr. LUJAN. Thank you.

Thank you, Mr. Chairman.

Senator DOMENICI. Thank you very much, Congressman.

Dr. Decker, let me first say that, from my standpoint, we welcome your involvement in DOE and your genuine interest in the area of technology transfer and the emphasis that you bring to the office.

Frankly, I don't believe I can overstate the case. I believe, whether the number is 20 billion that we use in one description of spending money, through part of the Federal system, for research, or the 58 that has been used here, that is much broader in terms of all the areas, much beyond DOE, I personally can't stress enough to you the fact that it is imperative that we take some risks.

For instance, you answered the question with reference to the weapons labs, and it's already understood here that they do not qualify for the automatic patent availability. Even if it isn't working too well, they don't even qualify, and that they have to go back up through you all, and you indicated a reluctance based upon a couple of things, sensitive information, if I gather your answer, and second, you indicated that they have a primary role and you wouldn't want them holding the research because they might get a patent when it ought to be available within the institutional framework of its original intent, military research.

Frankly, I urge that you give serious consideration to, if there's a risk, that you come down on the side of transfer and availability in the private sector—unless it involves security. And, obviously, the Congressman has established with you that they make that decision already, what's sensitive and what isn't. But, frankly, I believe, with that much money going into research, and such a shortage of money elsewhere in the Government—and it is there and it will be there for a long time—that unless we make the decision to prove the worth of some of that research in a more understood manner by the average person and by the average businessman and business company, I think the pressure to reduce the level and spend it some other way is growing. That's a practical, programmatic reason, but I honestly believe that, if you look across the land and see how much of the excellence is in the labs and in the Government research, and how much money, compared to what the private sector has and can put in, and the already-diminished role of the universities because of the shortage of the extreme amounts of money needed for the research equipment, it just seems to me that, you know, a country at risk was not only a description for education but it's that for productivity, it's that for competitiveness.

I just want to take this occasion in public, on the record, to urge that you encourage the Department of Energy to take the side of risking in further use of the research in the private sector rather than any other.

We will develop here today with the witnesses—and I hope you're here and listen—some of the problems that the labs have and some of the problems that the private sector has—and they're serious. I mean, we're just not getting it done, and that does not diminish the excellent role that the technology transfer experts are doing. They'll tell us they're doing great. But I think the private sector looks at it and they're not so sure that there's a cost-benefit ratio that comes anywhere close. That isn't, as I said before, to say they're doing so great. They have some bureaucratic hangups that are extreme, especially in the big companies, on new ideas.

I wonder if you would for the record, since clearly we wouldn't expect you to have it now, could you give us answers to the questions on waivers, how many have been granted, how long it's taking, with reference to patents that have been granted to those labs that are under your direct jurisdiction, how long it is taking to get them done, and what the problem, as you see it objectively, is in the slowness of that process? Could you get those out of the records and from your collaborators and answer that for this record?

Dr. **Decker**. Surely. We would be glad to do that.

[The information follows:]

The DOE Office of General Counsel does not keep statistics on the number of patents granted or the average time it takes to grant title. The Committee staff met with the DOE Assistant General Counsel for Patents and reviewed current and past patent requests (about 950) and reviewed pending requests. This discussion satisfied the Committee's inquiry. The list of past and current patent requests provided to the Committee are attached.

ADVANCE & IDENTIFIED WAIVER DOCKET

C - Closed

CL - Closed

CL/CW - Closed in favor of Class Waiver

D - Denied

G - Granted

P - Pending

PV - Pending w/Assigned Attorney

PW - Pending w/Moser

PX - Pending w/Lambert

PY - Pending w/Programmer

PZ - Pending w/Constant

WD - Withdrawn

WD/CW - Withdrawn in favor of Class Waiver

ATY - Attorney

GRP - Group

Updated: October 29, 1986

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
699	84-008	Engelhard Industries	84/01/06	P			CH	Fuel Cell Electric Power	S-59,530
744	84-054	Stetter, Joseph R.	84/04/19	P			CH		S-59,136
745	84-055	Stetter, Joseph R.	84/04/19	P			CH		S-59,152
746	84-056	Stetter, Joseph R.	84/04/19	P			CH		S-60,857
752	84-062	Engelhard Industries	84/01/04	P			CH	Fuel Cell Electric Power Production	S-59,530
753	84-063	Dow Chemical Co.	84/05/29	P			CH	Water Treatment Chelating Agents	S-59,569
761	84-071	Midwest Research Inst.	84/10/23	P			CH	Tracking System for Solar Collector	S-51,751
780	85-006	Thermo Electron	85/03/12	P			CH	Ceramic Heat Exchanger	S-62,687
785	85-011	Princeton University	85/03/07	P			CH	X-ray Laser Target	S-62,692
786	85-012	Princeton University	85/03/04	PW	85/05/07	RAL	CH	X-ray Laser	S-61,312
790	85-016	Princeton University	85/03/07	P			CH	Lasers	S-62,900
791	85-017	Princeton University	85/03/07	PX	85/05/?	RAL	CH	Lasers	S-62,902
794	85-020	United Technologies Corp.	82/05/24	P			CH	Separation Germanium	S-56,635
857	85-083	Steinberg, Meyer	85/08/26	P			CH	Flash Pyrolysis of Coal & Biomass	DE-AC02-76CH---16
872	85-098	University of Chicago	85/11/14	PY	86/10/06	RAL	CH	Combined Sensor Device for Detecting Tox	S-59,136 W-31-109-ENG-38
873	85-099	University of Chicago	85/11/14	PY	86/10/06	RAL	CH	Sensor Array for Toxic Gas Detection	S-59,152 W-31-109-ENG-38
874	85-100	University of Chicago	85/11/14	PY	86/10/06	RAL	CH	Electrochemical Methane Sensor	S-60,857 W-31-109-ENG-38
875	85-101	University of Chicago	85/11/14	PY	86/10/06	RAL	CH	Selective Chemical Detection by Energy	S-62,398 W-31-109-ENG-38
876	85-102	University of Chicago	85/11/14	P			CH	Hoziontal Electro Magnetic Casting of	S-62,969 W-31-109-ENG-38
943	86-060	Iowa State University	85/06/03	PY	86/10/09	RAL	CH	Forming Magnato Strictive Rods	W-7405-ENG-82; S-62,684
947	86-064	EG&G Idaho, Inc.	86/06/17	P			CH	At Article Yeilding Ultra-Fine Powder	DE-AC07-76ID-01570; S-65,030
951	86-067	Chicago, Univ. of	86/07/21	PY	86/10/06	RAL	CH	SARISA	W-31-109-ENG-38; S-61,362
952	86-068	Chicago, Univ. of	86/07/21	PY	86/10/06	RAL	CH	Photo Ion Spectrometer	W-31-109-ENG-38; S-64,182
955	86-071	Iowa State University	86/08/19	P			CH	Casting Tertenol by Bottom Pouring Techn	W-7405-ENG-82; S-64,345

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
743	84-053	Anderson, Herbert L.	84/07/12	PZ	86/10/06	RAL	AL	Magnetic image projector	S-60,004; W-7405-ENG-36
856	85-082	Calif., Univ. of	85/09/27	PX		RAL	AL	Apparatus for Unilateral Generation etc.	S-61,001; W-7405-ENG-36
865	85-091	Sandia Corp.	85/11/13	P			AL	Strained-Layer Superlattice Technology	S-56,737; DE-AC04-76DP00789
867	85-093	Sandia Corp.	85/11/13	P			AL	Strained Layer Superlattice Technology	S-58,874 DE-AC0476-DP00789
868	85-094	Sandia Corp.	85/11/13	P			AL	Strained Layer Superlattice Technology	S-59,800 - DE-AC0476DP00789
869	85-095	Sandia Corp	85/11/13	P			AL	Strained Layer Superlattice Technology	S-59,815 DE-AC0476DP00789
870	85-096	Sandia Corp.	85/11/13	P			AL	Strained Layer Superlattice Technology	S-61,210 DE-AC0476DP00789
871	85-097	Sandia Corp.	85/11/13	P			AL	Strained Layer Superlattice Technology	S-61,253 DE-AC0476DP00789
880	85-106	Wipf, Stefan L. (Univ. of CA)	85/12/09	P			AL	Magnetic Field Transfer Device	S-62,242; W-7405-ENG-26
897	86-014	Calif., Univ. of Reg.	86/01/02	P			AL	Device For Simul. Measurement of Floures	S-63,209; W-7405-ENG-36
912	86-029	Allied Corp.	86/03/13	P			AL	Flexible Delayed Cure Bismaleimide	S-63,478; DE-AC04-76DP00613
914	86-031	Petranto, Joseph J.	86/04/07	P			AL	Improved Split Gland	S-62,239; W-7405-ENG-36
915	86-032	Johnson, James	86/04/07	P			AL	Shock Induced Hydraulically-Driven Fract	S-63,237; W-7405-ENG-36
916	86-033	Hull, Donald, et al	86/04/08	P			AL	Combination Induction Plasma Tube...	S-63,220; W-7405-ENG-36
920	86-037	Kruse, Herold W.	86/04/28	P			AL	Fiber Optic Converter	S-63,238; W-7405-ENG-36
941	86-058	Calif., Univ. of (Krausse)	86/05/23	P			AL	Axial Flow Plasma Shutter	S-63,227; W-7405-ENG-36

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
775	85-001	Rockwell Intl. Corp.	84/09/11	PZ	86/10/06	RAL	LLL	Non-Oxide Silicon Compounds	S-62,701; DE-AC03-78ER01885
777	85-003	GTE Products Corp.	84/09/19	PX	85/03/18	RAL	LLL	Pumping Neodymium Gas	S-60,332
788	85-014	Calif., Univ. of Reg. (Birx)	85/03/18	P			LLL	Electron Beam Accelerator	S-61,414; DE-AC03-76SF00098
823	85-049	GTE Corporation	85/06/25	P			LLL	Efficacy/Fluorescent Lamp	S-63,039; DE-AC03-76SF00098
824	85-050	GTE Corporation	85/06/25	PX	85/11/06		LLL	Improving Fluorescent Lamps	S-62,059; DE-AC03-76SF00098
825	85-051	GTE Corporation	85/06/25	PX	85/11/26	RAL	LLL	Control of Materials in Electric Dischg	S-60,994; DE-AC03-76SF00098
826	85-052	GTE Corporation	85/06/25	PX	85/11/26	RAL	LLL	Photochemical Reactions	S-62,056; DE-AC03-76SF00098
827	85-053	GTE Corporation	85/06/25	PX	85/11/26	RAL	LLL	Preparing Mercury w/Isotopic Distrib	S-62,060; DE-AC03-76SF00098
830	85-056	Calif., Univ. of (Hirschfeld)	85/06/13	PX	85/12/?	RAL	LLL	Method for Measuring Temp & Pressure	S-60,408; W-7405-ENG-48
842	85-069	Rockwell International	85/07/11	PZ	86/10/06	RAL	LLL	Separation Uranium-Magnesium Flouride	S-62,797; DE-AT03-83SF11948
844	85-071	Rockwell International	85/07/11	PZ	86/10/06	RAL	LLL	Decontamination of Magnesium Flouride	S-62,079; DE-AT03-83SF11948
861	85-087	Calif., Univ. of Reg. (Leung)	85/08/26	PY	86/09/29	RAL	LL	Directly Heated LaB6 Hairpin Filament	S-59,000 DE-AC03-76SF00098
862	85-088	Hinrichs, Curtis Keith	85/07/26	PW	86/09/23	RAL	LL	Transparent Conductive Substrates etc.	S-60,222; DE-AC08-83NV10282
863	85-089	Hughes Aircraft Co.	85/07/02	P			LL	Sulfuric Acid Converter of Heat to Elect	S-63,033; DE-AC03-83SF11942
864	85-090	Stampfer, Martha R. et al	85/07/01	PW	86/06/12	RAL	LL	Enhanced Growth Medium-Culturing Mammary	S-63,826; DE-AC03-76SF00098
902	86-019	Calif., Univ. of Reg. (Berman)	86/01/03	PX	86/05/06	RAL	LLL	A Surface Wave Fluorescent Lamp	S-62,793; DE-AC03-76SF00098
922	86-039	Calif., Univ. of (Engelstad)	86/02/11	P			LLL	Paramagnetic Iminodiacetates...	S-63,076; DE-AC03-76SF00098
925	86-042	GTE Products Corp.	86/03/07	PW	86/07/24	RAL	LLL	Method/Apparatus Monit. Flow of Mercury	S-62,058; DE-AC03-76SF00098
944	86-061	Love, William H.	86/04/25	PY	86/10/09	RAL	LLL	Mircoscopic examin. opaque polished spec	S-63,859; W-7405-ENG-48
954	86-070	Calif., Univ. of (Gray)	86/07/07	PZ	86/10/06	RAL	LL	Detect. of Chromosomal Translocations...	W-7405-ENG-48; S-61,481
956	86-072	Hunt, Arlon J.	86/07/31	P			LL	Low Loss Microporous Glazing Materials	DE-AC03-76SF00098; S-63,006
957	86-073	Calif., Univ. of (Vanderlaan)	86/07/31	PZ	86/10/06	RAL	LL	Monoclonal Antibodies for Detect. Dioxin	W-7405-ENG-48; S-64,579
959	86-075	Calif., Univ. of (CIP)	85/03/07	PX	86/09/30	RAL	LL	Electron Beam Accelerator	W-7405-ENG-48; S-64,590
960	86-076	Calif., Univ. of (Halverson)		P			LL	Boron Carbide, Boron, & Boride-Reactive	W-7405-ENG-48; S-65,119
961	86-077	Maimoni, Arturo		P			LL	Lamellar Settler-Crystallizer	W-7405-ENG-48; S-62,756
962	86-078	Calif., Univ. of (Jensen)		P			LL	Monoclonal Antibodies to Human Hemoglobi	W-4705-ENG-48; S-62,093
963	86-079	Calif., Univ. of (Grav)		P			LL	Nucleic Acid Probes for in Situ Hybridiz	W-7405-ENG-48; S-64,587

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
695	84-004	Calif., U. of (Iwanczyk)	84/01/23	P			NV	Mercuric Iodide Detector	S-60,200; DE-AT03-76EV72031

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
710	84-019	Whitten, W.B., et al	84/03/22	P		RAL	OR	Self-scanning CW dye laser	S-61,121; W-7405-ENG-26
712	84-021.	Lauf, Robert	84/03/08	PX	86/07/03	RAL	OR	Low temperature alloy	S-61,175; W-7405-ENG-26
731	84-041	Carrier Corp.	84/05/29	P			OR	Absorption Cycling	S-60,517
732	84-042	Carrier Corp.	84/05/29	P			OR	Coupled dual loop	S-59,992
733	84-043	Carrier Corp.	84/05/29	P			OR	Absorption Cycle	S-59,996
734	84-044	Carrier Corp.	84/05/29	P			OR	Heat pipe coupling	S-60,522
737	84-047	Siomos, Konstadinos	84/06/05	P			OR	Liquid Phase Multiphoton	S-61,820
798	85-024	Rockwell Intl. Corp.	85/06/24	P			OR	Gasification of Black Liquor	S-62,565; DE-AC05-80CS40341
806	85-032	Martin Marietta	84/11/26	P			OR	Dynamic Gas Blazer	S-59,925; DE-AC05-84OR21400
807	85-033	Martin Marietta	84/11/26	P			OR	Clarification Process	S-59,963; DE-AC05-84OR21400
809	85-035	Martin Marietta	84/11/26	P			OR	Advanced Servo Manipulator	S-60,513; DE-AC05-84OR21400
810	85-036	Martin Marietta	84/11/26	P			OR	Centrifuge Damper Fluids	S-60,595; DE-AC05-84OR21400
812	85-038	Martin Marietta	84/11/26	P			OR	Alarm Circuit Optical Interface	S-61,826; DE-AC05-84OR21400
813	85-039	Martin Marietta	84/11/26	PX			OR	Expanding Mandrel	S-59,987; DE-AC05-84OR21400
814	85-040	Martin Marietta	84/11/26	P			OR	Servo Manipulator	S-60,520; DE-AC05-84OR21400
815	85-041	Martin Marietta	84/11/26	P			OR	Pulsed Helium Ionization Detection	S-61,846; DE-AC05-84OR21400
816	85-042	Martin Marietta	84/11/26	P			OR	Extended Range Counting	S-61,834; DE-AC05-84OR21400
817	85-043	Martin Marietta	84/11/26	P			OR	Servo Manipulator, Electromechanical	S-61,896; DE-AC05-84OR21400
818	85-044	Martin Marietta	84/11/26	P			OR	Servo Manipulator, Dual Arm	S-61,874; DE-AC05-84OR21400
820	85-046	Martin Marietta	84/11/26	P			OR	Electro Chemical Operation	S-61,848; DE-AC05-84OR21400
821	85-047	Martin Marietta	84/11/26	P			OR	Disposal of High Level Nuclear Waste	S-61,111; DE-AC05-84OR21400
822	85-048	Martin Marietta	84/11/26	P			OR	Charged Particle Detector	S-61,854; DE-AC05-84OR21400
833	85-059	Martin Marietta	85/11/26	P			OR	Fiber Reenforced Ceramic Composites	S-61,153; DE-AC05-84OR21400
834	85-060	Martin Marietta	85/11/26	P			OR	Vapor Deposition	S-61,925; DE-AC05-84OR21400
835	85-061	Martin Marietta	85/11/26	P			OR	Plastic Semiconductor	S-61,853; DE-AC05-84OR21400
836	85-062	Martin Marietta	85/11/26	P			OR	Joining Ceramics to Metals	S-61,894; DE-AC05-84OR21400
839	85-065	Martin Marietta	85/04/02	P			OR	Metallic Glass Composition	S-61,831; DE-AC05-84OR21400
840	85-066	Martin Marietta	85/04/02	P			OR	Long Range Ordered Alloys	S-61,824; DE-AC05-84OR21400
853	85-067	Martin Marietta	85/11/26	P			OR	Filles Materials	S-62,523/S63,538
841	85-068	Martin Marietta	85/04/02	P			OR	Brazing of Structural Ceramics	S-62,552; DE-AC05-84OR21400
851	85-078	Oak Ridge Associated Univ.	85/08/14	P		RAL	OR	1-alkyl-2-acetyl-sn-glycerol	S-60,597
860	85-086	Martin Marietta	85/09/30	P			OR	NiAl and NiFeAl for Oxidizing Env.	S-63,604
877	85-103	Techn. Corr. Instrum., Inc.	85/11/25	P			OR	Integrated Heat Generating & Sensing Sys	S-62,525 W-7405-ENG-26
878	85-104	TCI, Inc.	85/11/25	P			OR	Segmented Heater Cable	S-62,581
879	85-105	MW Kellogg Company	85/12/04	P			OR	Circulating Fluid Bed Combustion	S-62,562;S-63,565 - S-63,568
885	86-002	Martin Marietta	85/12/30	P			OR	Whole Blood Samples in a Centrifuge...	S-61,810; DE-AC05-84OR21400
888	86-005	Martin Marietta	85/12/27	P			OR	Radio Pharmaceutical Agent for Brain Ima	S-63,511; DE-AC05-84OR21400

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
889	86-006	Martin Marietta	85/12/27	P			OR	Heat Pumps Thermal Energy Storage System	S-62,546; DE-AC05-84OR21400
890	86-007	Martin Marietta	85/12/27	P			OR	Vibrational Excitatimal Induced Descrip.	S-62,541; DE-AC05-84OR21400
891	86-008	Martin Marietta	85/12/27	P			OR	Surface Enhanced Riman Spectropy	S-61,868; DE-AC05-84OR21400
892	86-009	Martin Marietta	85/12/27	P			OR	Radioiodentdle Iodoriyale Methyl-teranc.	S-62,539; DE-AC05-84OR21400
893	86-010	Martin Marietta	85/12/27	P			OR	Improved Gas Hydrodrate Coal Storage Sys	S-61,832; DE-AC05-84OR21400
894	86-011	Martin Marietta	85/12/27	P			OR	Improved Asmium-191-eridem-191 Radionucl	S-61,155; DE-AC05-84OR21400
895	86-012	Mossman, C. A. etal	86/01/09	P			OR	Cable Recognition Circuit	S-59,299; W-7405-ENG-26
896	86-013	Mossman, C. A. etal	86/01/09	P			OR	Cable Recognition Circuit	S-59,257; W-7405-ENG-26
900	86-017	McCulloch, R. W.	86/01/23	P			OR	Integrated Heat Generating & Sensing Sys	S-62,525
901	86-018	McCulloch, R. W.	86/01/23	P			OR	Segmented Heater Cable	S-62,581
917	86-034	Mechanical Technology, Inc.	86/04/15	P			OR	External, Tubed Vibration Absorber-HAHP	86X-47985V
923	86-040	International Fuel Cells	86/05/05	P			OR	Distortion Resistant Cell Stack in Plate	DE-AC21-79ET15440
924	86-041	Great Lakes Research Corp.	86/06/05	P			OR	Weir Impregnator	S- ;DEN3-369
926	86-043	Martin Marietta	86/05/19	P			OR	High Productivity Biacatalyst Beads	S-62,550; DE-AC05-84OR214000
927	86-044	Martin Marietta	86/05/19	P			OR	Architecture for Production Rule Systems	S-63,610; DE-AC05-84OR214000
929	86-046	Martin Marietta	86/05/19	P			OR	Closed-Loop Pulsed Helium Ionization Det	S-63,613; DE-AC05-84OR214000
930	86-047	Martin Marietta	86/05/19	P			OR	Lead Phosphate Glass Composition-Optical	S-63,618; DE-AC05-84OR214000
931	86-048	Martin Marietta	86/05/19	P			OR	Triple Effect Absorption Chiller 2 Refri	S-63,645; DE-AC05-84OR214000
933	86-050	Martin Marietta	86/05/19	P			OR	Alignment Device Coupling Optical Fibers	S-63,654; DE-AC05-84OR214000
934	86-051	Martin Marietta	86/05/19	P			OR	Biocatalyst Beads Incorporated Absorbent	S-63,665; DE-AC05-84OR214000
935	86-052	Martin Marietta	86/05/19	P			OR	Anaerobic Biocatalyst Beads	S-63,668; DE-AC05-84OR214000
936	86-053	Martin Marietta	86/05/19	P			OR	Radiohalogenated Branched Carbohydrates	S-63,679; DE-AC05-84OR214000
937	86-054	Martin Marietta	86/05/19	P			OR	Advanced System-Prod. Biocatalyst Beads	S-63,677; DE-AC05-84OR214000
938	86-055	Martin Marietta	86/05/19	P			OR	Rotor/Disk Syst. Auto. Proc. Whole Blood	S-63,682; DE-AC05-84OR214000
939	86-056	Martin Marietta	86/05/19	P			OR	Absorption Heat Pump-2 Refriger. Circuit	S-63,687; DE-AC05-84OR214000
942	86-059	Anderson, Mary Ruth	86/05/30	P			OR	Measuring Jig for Tubing & Pipe	S-62,524; DE-AC05-84OR214000
946	86-063	Singh, Suman P.N.	86/06/27	P			OR	Side Window Defogger/Deminster for Auto.	S-64,929; DE-AC05-84OR21400
953	86-069	Rockwell International	86/07/24	P			OR	Molten Salt Shatter System	DE-AC05-80CS40341; S-
964	86-080	Ferrell, T. L. et al	86/10/06	P			OR	Improved Substrate in Raman Spectroscopy	W-7405-ENG-26; S-63,659

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
614	83-026	Duracell International	83/02/23	PX	86/02/03	KDI	SAN	Solid State Storage	S-56,333; W-7405-ENG-26
715	84-024	Calif., Univ. of (Hammond)	84/01/06	P			SAN	m-Aminophenols	S-57,368
854	85-080	GTE Corporation	85/06/25	P			SAN	Recovery of Mercury via Electrolytic	S-60,989, S-60,993; 76SF0009
919	86-036	Calif., Univ. of	86/03/31	P			SAN	Method Producing Narrow Band Ultra-Viole	S-64,543; DE-AC03-76SF00098

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
263	79-027	(No. was missed)							
217	79-072	(no. was missed)							
453	81-069	(Same as W(I)-81-063)							
477	81-093	(Same as W(I)-81-076)							
493	82-015	(See W(I)-81-014)							
494	82-016	(See W(I)-81-014)							
56	77-017	Abacus Controls Inc.	77/08/16	G	77/12/08	NEA	HQ	Inverter Control	
122	78-052	Adelphi University	78/11/01	G	80/10/09	WRM	HQ	Nozzle	
417	81-034	Advanced Mech. Tech., Inc.	81/03/12	C	83/06/01	RAL	OR	Water Heaters	S-54,886
418	81-035	Advanced Mech. Tech., Inc.	81/03/12	C	83/06/01	RAL	OR	Water Heaters	S-54,887
384	80-113	Aerochem Research Lab.	80/11/25	WD/C	81/05/01	KDI	HQ	Produce Silicon	JPL 955491
272	79-120	AiResearch Manu. Co.	79/11/26	G	80/07/30	RAL	HQ	Rotating Machine	NASA DEN-3-77
848	85-075	Alex Harvey	85/08/01	WD	85/10/04	RAL	AL	Composite Vacuum Tube	S-63,236
71	78-001	Allied Chemical Corp.	78/02/01	D	79/03/09	RAL	CH	Recycling Zeolite	S-47,510, Pat. 4,088,737
912	86-029	Allied Corp.	86/03/13	P			AL	Flexible Delayed Cure Bismaleimide	S-63,478; DE-AC04-76DP00613
186	79-041	Amerace Corporation	79/06/14	G	79/07/05	RJM	BAO	Heat Transfer	S-47,447, P# 4,034,151
187	79-042	Amerace Corporation	79/06/14	G	79/07/05	RJM	BAO	Electrical Cable	S-47,446, P# 4,054,743
188	79-043	Amerace Corporation	79/06/14	G	79/07/05	RJM	BAO	Electrical Connector	S-47,471, S.N. 861,416
189	79-044	Amerace Corporation	79/06/14	G	79/07/05	RJM	BAO	Splice Sleeve	S-47,472, S.N. 877,683
191	79-046	Amerace Corporation	79/06/14	G	79/07/05	RJM	BAO	Cable Shield	S-47,425, S.N. 822,947
571	82-093	Ames Laboratory	82/09/23	G	83/08/23	PAL	CH		S-55,482
572	82-094	Ames Laboratory	82/09/23	G	83/10/26	RAL	CH		S-53,807
495	82-017	Amoco	82/03/29	G	83/01/31	KDI	CH	Coal Liquefaction Catalyst	S-57,128
743	84-053	Anderson, Herbert L.	84/07/12	P			AL	Magnetic image projector	S-60,004; W-7405-ENG-36
942	86-059	Anderson, Mary Ruth	86/05/30	P			OR	Measuring Jig for Tubing & Pipe	S-62,524; DE-AC05-84OR214000
487	82-009	Anderson, Norman L.	82/01/29	WD	82/09/30	RJM	CH	Apparatus for Electrophoresis Separ.	S-48,679
488	82-010	Anderson, Norman L.	82/01/29	WD	82/09/30	RJM	CH	System for Load Slab Holders Elec. Sep.	S-48,680
779	85-005	Andrews, John	85/03/11	G	85/05/29		CH	Air Conditioning	S-61,389
8	75-008	Anger, H. O.	75/10/26	CL	77/05/06	RMP	HQ	Tomographic Scanner	S-44,942
306	80-034	Applied Physics Lab.	80/04/21	WD/C	81/04/21	MS	HQ	High Speed TV System	S-56,893 SPL-129
307	80-035	Applied Physics Lab.	80/04/21	WD/C	81/04/21	MS	HQ	Soft Motor Mount	S-56,893 SPL-117
405	81-022	Archuleta, Ruben F.	81/02/24	CL	81/07/08	RAL	AL	"Nose Only" Device	S-53,329
406	81-023	Archuleta, Ruben F.	81/02/24	C	81/07/08	RAL	AL	Body Inhalation Cham.	S-55,728
61	77-022	Arizona, Univ. of	77/10/12	G	79/03/02	RAL	AL	Nox Control	S-48,739
72	78-002	Arizona, Univ. of	78/05/22	G	79/03/02	RAL	AL	Pulverized Coal	S-49,453
81	78-011	Arizona, Univ. of	78/09/19	D	78/10/27	RMP	CH	Electric Components	S-49,825
192	79-047	Arizona, Univ. of	79/07/05	D	80/07/16	MS	AL	Refractory Films	S-52,035

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
246	79-101	Arizona, Univ. of	79/09/20	D	80/07/16	RAL	AL	Molybdenum	S-52,109
434	81-050	Artech Corp.	80/10/06	WD	83/05/20	KDI	HQ	Thermal Energy Storage	NAS8-32254
910	86-027	Associated Univ., Inc.	85/05/28	G	86/04/17	RAL	CH	Cloning & Expressions Gene for Bacteriop	S-64,618; DE-AC02-76CH00016
781	85-007	Associated Universities	85/01/28	G	86/04/17	RAL	CH	Catalytic Production Carbonyls	S-60,607
782	85-008	Associated Universities	85/01/14	WD	85/05/08	RAL	CH	Thin Film Absorber	S-61,364
783	85-009	Associated Universities	85/01/14	G	86/04/17	RAL	CH	Selective Labeling	S-64,395
784	85-010	Associated Universities	85/01/14	G	86/04/17	RAL	CH	Methanol Productions	S-64,199
26	76-013	Atomics International Div.	74/12/06	G	76/04/22	NEA	SAN	Filter Vapor Trap	S-43,167
348	80-076	Babcock & Wilcox	80/09/17	D	82/02/26	RAL	RL	Nuclear Reactor App.	S-55,001
349	80-077	Babcock & Wilcox	80/09/17	D	82/02/26	RAL	RL	Nuclear Reactor App.	S-55,002
350	80-078	Babcock & Wilcox	80/09/17	D	82/02/26	RAL	RL	Nuclear Reactor App.	S-55,003
479	82-001	Babcock & Wilcox	82/01/05	G	82/02/18	RAL	CH	Upper End Fit. Des. Removable Fuel Rods	S-57,112
480	82-002	Babcock & Wilcox	82/01/07	D	83/07/21	RAL	RL	PWR Nonbackfit. Fuel & Reat. Core Des.	S-56,447
940	86-057	Banerjee, Sujit	86/05/09	PY	86/07/21	RAL	CH	Nonelectrolytes-Liquid Charomatography	S-62,993; DE-AC02-76CH00016
299	80-027	Barber-Nichols Eng. Co.	80/03/26	G	80/07/11	RAL	HQ	Self-governing Purge	NASA W-2093
300	80-028	Barber-Nichols Eng. Co.	80/03/26	G	80/07/11	PAL	HQ	Gearbox Lub	NASA W-2090
541	82-063	Barclay, John A.	82/07/06	C	83/02/04	RAL	AL	Magnetic Helium Liquifier	S-57,937
755	84-065	Barclay, John A.	84/08/31	G	85/02/22		AL	Wheel Type Magnetic Refrigerator	S-55,700
756	84-066	Barclay, John A.	84/08/31	G	85/02/22		AL	Low Temperature Magnetic Refriq.	S-57,261
757	84-067	Barclay, John A.	84/08/31	G	85/02/22		AL	Magnetic Refriq. Apparatus & Method	S-58,904
758	84-068	Barclay, John A.	84/08/31	G	85/02/22		AL	Regenerate Mag. Refrig.	S-61,039
422	81-017	Barnes, Paul R.	31/01/19	G	81/05/20	RAL	OR	Solar Window	S-54,819
557	82-079	Battelle	82/08/25	WD	83/12/15	RAL	CH		S-53,869
558	82-080	Battelle	82/08/25	WD	83/06/29	RAL	CH		S-52,589
559	82-081	Battelle	82/08/25	G	84/10/25	RAL	CH	Enhancement of sulfer capture	S-55,437
702	84-011	Battelle Memorial Inst.	84/02/24	G	84/10/25	RAL	RL	Long Term Control of Root Growth	S-54,938
156	79-010	Baumann et al. (Empl/Inv)	79/02/27	WD	80/03/05	RJM	AL	Specimen Carrousel	S-48,531
646	83-057	Benjamin, Robert F.	83/08/11	G	84/02/28		AL	Optical Pin Using Flash-Gap	S-59,360
284	80-013	Bernd Ross Associates	80/02/07	WD/C	81/03/27	RAL	HQ	Screenable Contact	JPL-955164
320	80-048	Bissell, et al. (U. of CA)	80/05/30	G	80/11/17	JWG	SAN	Enyzme Assay Method	S-54,523/S-54.427
48	77-009	Block Engineering, Inc.	77/05/24	G	77/08/25	RAL	BAO	Spectrometric	S-48,838, S.N. 959,426
294	80-023	BNL/Associated Univ.	80/03/14	G	82/04/12	RAL	BAO	Anti-Coagulant Peptide	S-53,105
413	81-030	Boeing Aerospace Co.	80/11/18	G	81/04/20	RAL	CH	Solar Cells	S-55,421
414	81-031	Boeing Aerospace Co.	80/11/18	G	81/04/20	RAL	CH	Solar Cells	S-55,423
751	84-061	Boeing Engineering Co.	84/08/28	WD	84/10/02		OR	Inspection Repair Robot	S-61,864
169	79-023	Bowen, Ray J.	79/05/21	G	79/08/24	RAL	HQ	Pillar Extraction	S-52,345
584	82-106	Brassell, G. W.	82/12/30	G	84/02/07	KDI	AL	Carbon Bonded Vents for Radioactive	S-56,788

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
271	77-004	Brooklyn College	77/00/00	G	77/00/00	KLC	HQ		
57	77-018	Calif. Inst. of Tech.	77/08/23	D	77/12/21	NEA	HQ	Photovoltaics	S.N. 706,073
228	79-083	Calif. Inst. of Tech.	79/04/09	G	80/08/27		SAN	Superconducting Glasses	S-49,307
261	79-115	Calif. Inst. of Tech.	79/03/05	G	80/05/16	RAL	HQ	Detection Method	S.N. 913,016
292	80-021	Calif. Inst. of Tech.	80/02/15	CL	81/11/19	RAL	BAO	Crude Oil Desulfur	S-30,831
346	80-074	Calif. Inst. of Tech.	80/09/04	G	81/03/19	RAL	HQ	Coal Desulfurization	S.N. 156,790
539	82-061	Calif. Inst. of Tech.	82/06/21	WD/C	83/10/29	KDI	HQ	Solar Cell Encapsulation and Method	S-59,312 & S-59,313
549	82-071	Calif. Inst. of Tech.	82/07/29	CL	83/04/19	RAL	HQ	Low Emission, High Effi. Engine Sys.	NAS7-100
564	82-086	Calif. Inst. of Tech.	82/08/23	CL	83/04/19	RJM	HQ	Fluid. Bed Sili. Dep. from Silane	S.N. 126,324
576	82-098	Calif. Inst. of Tech.	82/11/05	CL	83/04/19	RAL	NASA	Ultraviolet & Absorbing Copolymers	S-59,314 & 59,315
585	82-107	Calif. Inst. of Tech.	82/12/30	CL	83/04/19		HQ	Coal Desulfurization	S-
625	82-111	Calif. Inst. of Tech.	82/11/08	CL	83/04/19	RAL	HQ	Thermochemical Generation	S-59,349
589	83-001	Calif. Inst. of Tech.	83/01/06	CL	83/04/19		HQ	Charge Indicator for Battery Chargers	S-
598	83-010	Calif. Inst. of Tech.	83/02/10	CL	83/04/19		NASA	Hollow Cathode Apparatus	NPO-15560
599	83-011	Calif. Inst. of Tech.	83/02/10	CL	83/04/19		NASA	Ion Beam Accelerator System	NPO-15547
605	83-017	Calif. Inst. of Tech.	83/03/21	CL	83/04/19	RAL	HQ	Reactor Producing Parts/Mat'ls Gases	S-
606	83-018	Calif. Inst. of Tech.	83/03/21	CL	83/04/19	RAL	HQ	Internal Stabilization Poly Resins	S-
321	80-049	Calif., U. of	80/06/10	CL	81/11/04	RAL	AL	Sonar/Video System	S-54,427
411	81-028	Calif., U. of	81/01/29	CL	81/07/08	RAL	AL	Ionization of Gases	S-52,479
613	83-025	Calif., U. of	83/04/22	G	84/05/18	RAL	SAN	High Strength Steel Wire	S-58,722
644	83-055	Calif., U. of	83/06/23	G	84/08/13	RAL	SAN	Water Jet Assisted Drag Bit	S-59,473; S-58,713
723	84-033	Calif., U. of	84/05/20	G	84/05/25	RAL	AL	Virus identification apparatus	S-61,029
747	84-057	Calif., U. of	84/01/06	G	84/10/13	RJM	LLL	Synthesis of Group IV-B Nitrides	S-60,117
748	84-058	Calif., U. of	84/04/12	G	85/05/29	RJM	LLL	Measuring Nuclear Magnetic Prop.	S-60,966
749	84-059	Calif., U. of	84/04/16	G	84/11/02		LLL	Metal Vapor Vacuum	S-60,979
750	84-060	Calif., U. of	84/07/26	G	85/02/25	RAL	LLL	Rolling process for dual phase steels	S-61,431
565	82-087	Calif., U. of (Coon, et al)	82/08/30	G	84/11/09	KDI	SAN	Synthesizing Anhydrous HN03	S-58,120
461	81-077	Calif., U. of (Radziemski)	81/10/14	WD	82/04/22	RAL	AL	Laser Used Breakdown Spectroscopy	S-55,747
11	75-011	Calif., U. of (Ables)	75/09/23	CL	77/05/06	RAL	SAN	Oscilloscope Analysis	S-44,982
79	78-009	Calif., U. of (Anger)	78/02/06	D	82/03/26	KDI	SAN	Nuclear Imaging	S-47,364
542	82-064	Calif., U. of (Calvin & W.)	82/07/06	G	83/03/18	RAL	SAN	Photoenergy Conversion Process	S-57,379
231	79-086	Calif., U. of (Calvin)	79/08/01	G	80/05/02	RAL	SAN	Fuel Cell	S-52,726
436	81-052	Calif., U. of (E. Henze)	81/06/18	G	83/01/04	RAL	SAN	TC-99M Labeled Dextran	S-55,990
503	82-025	Calif., U. of (Gray)	82/02/10	WD	85/02/11	RAL	SAN	Method & Appar. Chromosome Analysis	S-55,162
224	79-079	Calif., U. of (Hampel)	79/03/01	G	80/08/27		SAN	Fallout Shelter	S-36,847
337	80-065	Calif., U. of (Hirschfeld)	80/07/30	G	83/05/05	RAL	SAN	Spectometry	S-53,633
566	82-088	Calif., U. of (Hirschfeld)	82/09/14	CL/CW	83/05/05	RAL	SAN	pH Sensitive Optrode	S-58,727

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567	82-089	Calif., U. of (Hirschfeld)	82/09/14	CL/CW	83/05/05	RAL	SAN	Pressure-Sensitive Optrode	S-58,728
610	83-022	Calif., U. of (Hirschfeld)	83/03/29	G	83/05/05	RAL	SAN	Temp. Sensitive Optrade	S-58,725
575	82-097	Calif., U. of (Holt)	82/09/21	G	84/10/13	RAL	SAN	Transition Metal Nitrides	S-58,705
691	83-102	Calif., U. of (Hutson)	84/01/23	G	84/04/11	RAL	AL	Corneal-Shapinging Electrode	S-53,307
695	84-004	Calif., U. of (Iwanczyk)	84/01/23	P			NV	Mercuric Iodide Detector	S-60,200; DE-AT03-76EV72031
13	75-013	Calif., U. of (Jenkins)	75/12/23	CL	77/05/06	RAL	SAN	Stablizing Plasma	S-44,209
563	82-085	Calif., U. of (LBL)	82/08/30	G	83/03/18	RAL	SAN	Rapid Brain Scanning Radiopharm.	S-58,130
22	76-009	Calif., U. of (Lieber)	76/03/29	G	76/09/04	WRM	HQ	Streak Camera Tube	S-44,788 (S.N. 608,379)
459	81-075	Calif., U. of (Maestre)	81/09/21	CL	83/03/18	RAL	SAN	Analy. of Optically Micro. Substances	S-54,562
129	78-059	Calif., U. of (Palzer)	78/04/14	G	80/05/02	RAL	SAN	Microscopy Chamber	S-48,904
145	78-075	Calif., U. of (Perez-Mendez)	78/12/13	G	80/07/23	RAL	SAN	Cancer Detection	S-50,569
223	79-078	Calif., U. of (Riveros)	79/01/31	G	80/07/16	WRM	SAN	Inductor Current Contr.	S-49,776
725	84-035	Calif., U. of (Saulzman)	84/05/07	WD	84/10/29		AL	Blood typing apparatus	S-60,466
45	77-006	Calif., U. of (Schwab)	77/03/23	G	77/12/21	WRM	SAN	Submerged Jet Cutter	S-46,862
663	83-074	Calif., U. of (Sheinberg)	83/08/31	G	84/12/17	RAL	AL	Nard Metal Composition	S-60,020
554	82-076	Calif., U. of (Somorjai)	82/09/14	G	83/03/07	RAL	SAN	Catalyzed Processing	S-57,380
694	84-003	Calif., U. of (Swann)	84/01/12	G	84/09/14		AL	Electron Laser Config.	S-60,033
662	83-073	Calif., U. of (Taylor)	83/08/31	G	84/10/15	KDI	AL	Prod. of Fluorocarbon Resin Bonded	S-60,003
150	79-004	Calif., U. of (Thomas)	79/02/12	G	79/05/07	RAL	SAN	Steel	S-48,954
12	75-012	Calif., U. of (Walker)	78/12/07	G	78/12/19	RAL	SAN	Modifying Explosives	S-44,268
137	78-067	Calif., U. of (West)	78/09/08	WD	80/12/01	RAL	SAN	Optical Computer	
280	80-009	Calif., U. of (Wheatley)	80/01/25	G	80/06/09	MS	SAN	Cryocoolers	S-53,602
281	80-010	Calif., U. of (Wheatley)	80/01/25	G	80/06/09	MS	SAN	Cryocoolers	S-53,604
282	80-011	Calif., U. of (Wheatley)	80/01/25	G	80/06/09	MS	SAN	Cryocoolers	S-53,603
550	82-072	Calif., U. of (Wolf, et al)	82/08/05	G	83/04/26	RAL	AL	Generic Radiac	S-58,421
251	76-028	Calif., U. of/LASL	76/09/23	WD	80/01/02	KLC	AL	Heat Transfer	S-46,630
706	84-015	Calif., Univ. of	83/12/29	WD	85/11/21	RAL	SAN	Improved monoclonal antibodies	S-60,122
707	84-016	Calif., Univ. of	84/01/10	G	86/04/17	RAL	SAN	Preparation of Thorium Dioxide Catalyst	S-59,437
708	84-017	Calif., Univ. of	84/01/10	G	86/05/30	RAL	SAN	Preparation of Methanol	S-59,441; W-7405-ENG-48
843	85-070	Calif., Univ. of	85/07/12	G	86/02/21	RAL	LLL	Coah-Edgecard Connector	S-62,778
845	85-072	Calif., Univ. of	85/07/30	G	85/12/16	RAL	AL	Electro0Micro Injection	S-62,241
856	85-082	Calif., Univ. of	85/09/27	PX		RAL	AL	Apparatus for Unilateral Generation etc.	S-61,001; W-7405-ENG-36
919	86-036	Calif., Univ. of	86/03/31	P			SAN	Method Producing Narrow Band Ultra-Viole	S-64,543; DE-AC03-76SF00098
772	84-073	Calif., Univ. of (Bergman)	84/11/21	PW	86/02/05	RAL	SAN	Conversion Hydrocarbon	S-60,380; DE-AC03-76SF00098
881	85-107	Calif., Univ. of (Bergman)	85/11/20	PW	86/02/05	RAL	SAN	Process for Fuctionalizing Methanes	S-63,822 DE-AC03-76SF00098
711	84-020	Calif., Univ. of (Dolbeare)	84/01/04	G	86/05/29	RAL	SAN	Flow Cytometric Measurement-Halodeoxyuri	S-58,183
908	86-025	Calif., Univ. of (Dolbeare)	84/01/06	G	86/05/29	RAL	LLL	Flow-Cytometric Measurement/Halodexyurid	S-61,486; W-7405-ENG-48

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909	86-026	Calif., Univ. of (Dolbeare)	84/01/06	G	86/05/29	RAL	LLL	Flow Cytometric Measurement-Nucleoside	S-63,069; W-7405-ENG-48
922	86-039	Calif., Univ. of (Engelstad)	86/02/11	P			LLL	Paramagnetic Iminodiacetates...	S-63,076; DE-AC03-76SF00098
832	85-058	Calif., Univ. of (Halverson)	85/07/02	G	86/07/17	RAL	LLL	Boron Carbide-Aluminum Cermet	S-62,782; W-7405-ENG-48
715	84-024	Calif., Univ. of (Hammond)	84/01/06	P			SAN	m-Aminophenols	S-57,368
792	85-018	Calif., Univ. of (Hirschfeld)	85/04/11	G	86/05/08	RAL	LLL	Aldehyde-Sensitive Optrode	S-60,376
793	85-019	Calif., Univ. of (Hirschfeld)	85/04/11	G	86/06/06	RAL	LLL	Nonsalurable Cartride	S-58,139
830	85-056	Calif., Univ. of (Hirschfeld)	85/06/13	PX	85/12/?	RAL	LLL	Method for Measuring Temp & Pressure	S-60,408; W-7405-ENG-48
941	86-058	Calif., Univ. of (Krausse)	86/05/23	P			AL	Axial Flow Plasma Shutter	S-63,227; W-7405-ENG-36
918	86-035	Calif., Univ. of (Loo, et al)	86/01/27	D	86/07/23	RAL	SAN	New Compton Densitometer Meas. Pulmonary	S-63,051; DE-AC03-76SF00098
944	86-061	Calif., Univ. of (Love)	86/04/25	P			LLL	Mircoscopic examin. opaque polished spec	S-63,859; W-7405-ENG-48
592	83-004	Calif., Univ. of (O'Connell)	83/01/14	WD	86/05/30	RAL	AL	Nonlinear Generation of Wave Beams	S-57,941; W-7405-ENG-36
945	86-062	Calif., Univ. of (Vanderlaan)	86/05/30	PX	86/08/04	RAL	LLL	Mono-clonal Antibodies-Hglodeoxyuridine	S-63,865; W-7405-ENG-48
773	84-074	Calif., Univ. of Reg.	84/11/21	P			AL	Improved Flow Cytometer Measurement	S-61,907; W-7405-ENG-36
855	85-081	Calif., Univ. of Reg.	85/09/18	D	86/07/23	RAL	AL	Method of Making Silicon Carbide Whisker	S-62,272 W-7405-ENG-36
882	85-108	Calif., Univ. of Reg.	85/07/29	G	86/04/24	RAL	AL	Electrosurg. Device/Mech. Cutting, etc.	S-62,249 - W-7405-ENG-36
897	86-014	Calif., Univ. of Reg.	86/01/02	P			AL	Device For Simul. Measurement of Floures	S-63,209; W-7405-ENG-36
902	86-019	Calif., Univ. of Reg. (Berman)	86/01/03	PX	86/05/06	RAL	LLL	A Surface Wave Fluorescent Lamp	S-62,793; DE-AC03-76SF00098
788	85-014	Calif., Univ. of Reg. (Birx)	85/03/18	P			LLL	Electron Beam Accelerator	S-61,414; DE-AC03-76SF00098
861	85-087	Calif., Univ. of Reg. (Leung)	85/08/26	PX	86/08/04	RAL	LL	Directly Heated LaB6 Hairpin Filament	S-59,000 DE-AC03-76SF00098
883	85-109	Calif., Univ. of Reg. (Melhorn	85/09/09	G	86/07/10	RAL	LLL	Method Loading Lipid Vesicles, etc.	S-61,419 - DE-AC03-76SF00098
693	84-002	Calif, U. of (Dongianni)	83/12/30	G	84/08/31	RAL	AL	Microminiature Coaxial Cable	S-60,027
690	83-101	Calif, U. of (Doss)	84/01/23	G	84/03/08		AL	Multipolar Corneal-Shaping	S-54,653
828	85-054	Calif, Univ. of	85/06/13	G	86/01/17	RAL	LLL	Differential Imaging Device	S-60,975
112	78-042	Carborundum Company	77/09/14	G	79/11/21	WRM	CH	Fiber Article	S-47,535
113	78-043	Carborundum Company	77/09/14	G	79/11/21	WRM	CH	Fiber Article	S-47,536, S.N. 773,588
731	84-041	Carrier Corp.	84/05/29	P			OR	Absorption Cycling	S-60,517
732	84-042	Carrier Corp.	84/05/29	P			OR	Coupled dual loop	S-59,992
733	84-043	Carrier Corp.	84/05/29	P			OR	Absorption Cycle	S-59,996
734	84-044	Carrier Corp.	84/05/29	P			OR	Heat pipe coupling	S-60,522
692	84-001	Castillo, Vincent J.	84/01/31	G	84/03/14	RJM	CH	Gasket Holder	S-59,177
190	79-045	Catalysis Research Corp.	79/07/02	WD/C	81/05/01	RAL	BAO	Catalysts	S-50,840
99	78-029	Chance, A. B., Co.	78/06/28	WD	80/10/20	JWG	HQ	Power Transmission	
687	83-098	Chapline, George F.	83/10/28	CL	85/03/15	RAL	SAN	Fabrication Integrated Circuits	S-59,448
688	83-099	Chapline, George F.	83/10/28	CL	85/03/19		SAN	Alignment of Projection Mask	S-59,449
666	83-077	Chapman, Loyd R., et al	83/10/03	G	85/11/22	RAL	OR	High Temp. Paint	S-60,571
504	82-026	Charles Cox & Thomas Warner	82/05/25	G	82/07/29	RAL	CH	Photovoltaic Measurement Device	S-55,887
102	78-032	Chicago, Univ. of	78/07/26	G	78/09/22	RMP	CH	Energy Collector	S-45,206, P# 4,002,499

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
771	84-073	Chicago, Univ. of		G	84/09/11	RAL	CH	See W(I)78-032	
951	86-067	Chicago, Univ. of	86/07/21	P			CH	SARISA	W-31-109-ENG-38; S-61,362
952	86-068	Chicago, Univ. of	86/07/21	P			CH	Photo Ion Spectrometer	W-31-109-ENG-38; S-64,182
430	81-046	Chicago, Univ. of (McIntive)	81/05/21	G	81/07/10	RAL	CH	Energy Collectors	S-51,020
431	61-047	Chicago, Univ. of (McIntive)	81/05/21	G	81/07/10	RAL	CH	Energy Collectors	S-53,819
429	81-045	Chicago, Univ. of (Winston)	81/05/21	G	81/07/10	RAL	CH	Tubular Absorbers	S-56,096
17	76-004	Chu, G. (Empl/Inv)	76/02/24	CL	77/05/06	RMP	HQ	Three-Dimension Camera	S-46,866
759	84-069	Chung-Hsuan Chen, et al	84/09/12	WD	86/06/05	RAL	OR	Tunable Vacuum Ultroviolet Lazur	S-61,151; W-7405-ENG-26
344	80-072	Cities Services Co.	80/09/05	G	80/12/19	JWG	SAN	Polymers	S-55,115
903	86-020	Clapp, Mireille Treuil	86/03/29	G	86/04/22	RAL	CH	Ion Implement. & Melt Spinning Supercond	S-62,633; DE-AC02-3ER-10566
227	79-082	Cline et al. (U. of CA)	79/04/03	G	79/11/16	RJM	SAN	Flaws from Laser Glass	S-48,240
512	82-034	Cline, Carl F.	81/02/19	G	84/10/13	RAL	SAN	Solid Solution of Beryllium in Alum.	S-55,997
486	82-008	Coblenz, William S.	82/03/08	G	82/04/06	RAL	CH	Press. Scintering Sil. Oyxgen Content	S-53,889
258	79-112	Colgate, Stirling A.	79/11/09	G	80/07/11	JWG	AL	Deep Drilling	S-53,311
367	80-096	Colmenares, C.A./McLean, W.	80/11/10	G	82/08/31	RAL	SAN	Thorium Oxide Catalyst	S-52,304
221	79-076	Columbus Products	79/07/18	GP	80/09/12		OR	Insulating Muffler	S-52,998
234	79-089	Columbus Products	79/07/18	G	80/09/12		OR	Insulating Muffler	S-52,209
235	79-090	Columbus Products	79/07/18	G	80/09/12		OR	Motor Compressor	S-52,210
236	79-091	Columbus Products	79/07/18	WD	80/09/30		OR	Motor Compressor	S-52,211
237	79-092	Columbus Products	79/07/18	G	80/09/12		OR	Motor Compressor	S-52,212
238	79-093	Columbus Products	79/07/18	G	80/09/12		OR	Motor Compressor	S-52,213
52	77-013	Combustion Engineering	76/07/16	D	79/11/07	RAL	BAO	Mass Flow Equalizer	S-46,343
689	83-100	Combustion Engineering	83/12/07	G	84/02/23		CH	Method of Controlling Gasifier	
709	84-018	Compere, A. L., et al	84/03/19	G	85/08/23	RAL	OR	Foams w/submicron cells	S-61,178
713	84-022	Compere, A. L., et al	84/03/28	G	85/08/23	RAL	OR	Microemulsions containing freon & water	S-61,179
716	84-025	Compere, A. L., et al	84/03/29	G	85/08/23		OR	Microshapes	S-61,186
704	84-013	Comperi, Alecia	84/03/01	CL	84/10/02	RAL	OR	Extraction of 1-Butanel	S-61,165
240	79-095	Condon, J. (Empl/Inv)	79/08/14	G	80/08/28	MS	OR	Diamond-like Carbon	S-49,015
105	78-035	Connecticut, Univ. of	78/06/05	G	79/07/10	RAL	BAO	Gasifying	S-49,673, S.N. 840,567
73	78-003	CONOCO Coal Develop. Co.	78/05/23	G	79/01/12	WRM	CH	Synthetic Acceptor	S-49,869
85	78-015	CONOCO Coal Develop. Co.	78/05/31	G	79/01/12	WRM	CH	Synthetic Acceptor	S-49,870
86	78-016	CONOCO Coal Develop. Co.	78/05/23	G	79/07/13	WRM	CH	Synthetic Acceptor	S-49,871
8	78-017	CONOCO Coal Develop. Co.	78/03/31	G	79/05/01	WRM	CH	Regen. of Syn. Acceptor	S-49,872
454	81-070	Cornell Research Foundation	81/08/03	WD/C	81/12/08	JWG	HQ	Methane Production by Attached Film	EY-76-S-02-2981
146	78-076	Cornell University	78/10/26	CL	79/02/28	RAL	BAO	Dopamine Analyogs	S-44,460, S.N. 812,854
291	80-020	Cornell University	80/03/04	WD/C	81/02/13	MS	HQ	Greenhouse Nightcover	S-53,975
25	76-012	Corser & France (Empl/Inv)	76/04/30	G	77/01/05	RJM	OR	Grinding Tool	S-47,153

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
287	80-016	Curtiss-Wright	80/02/14	G	83/07/20	RAL	BAO	Fuel Burner	S-53,111
514	82-036	Curtiss-Wright	82/05/19	G	83/07/20	RAL	CH	High Temp. Turbine Tech. Program	S-53,963
515	82-037	Curtiss-Wright	82/05/19	G	83/07/20	RAL	CH	High Temp. Turbine Tech. Program	S-53,198
516	82-038	Curtiss-Wright	82/05/19	G	83/07/20	RAL	CH	High Temp. Turbine Tech. Program	S-54,310
574	82-096	Curtiss-Wright	82/10/14	G	83/07/20	RAL	CH	Vaporizer Combustion, etc.	S-59,131
265	79-118	daRoza/Stephenson	79/12/21	G	80/07/11	MS	SAN	Aspirator	S-53,660
548	82-070	Davis, Brent A.	82/08/19	WD	83/05/31	RAL	NV	Picosecond FWHM, High Voltage, etc.	S-54,723
371	80-100	Davis, Glenn B.	80/03/24	WD	81/11/06	RAL	AL	Solar Collector Louver	S-50,888
657	83-068	Dawson, Igow & Neal	83/05/13	G	84/08/31	RAL	OR	Electrochemical Machine Operations	S-58,520
351	80-079	Delaware, Univ. of	80/10/01	WD/C	81/02/09	RAL	BAO	Photovoltaic	S-54,321
383	80-080	Delaware, Univ. of	80/10/01	WD/C	81/05/00	RAL	HQ	Photovoltaic	S-54,541, S.N. 146,323
372	80-101	Delaware, Univ. of	80/11/11	G	81/05/13	RAL	SAN	Amorphous Solar Cell	S-54,563
373	80-102	Delaware, Univ. of	80/11/11	G	81/05/13	RAL	SAN	Photovoltaic	S-54,564
376	80-106	Delaware, Univ. of	80/11/25	CL	81/05/13	RAL	SAN	Photovoltaic	S-55,108, S.N. 043,339
615	83-027	Dendix Corporation	83/05/09	G	83/09/29	RAL	AL	Thread Anvils for Vernier Caliper	S-57,899
624	83-036	DOL Dawson, et al	83/05/20	CL	84/31/08	RAL	OR	Restarting Electrochemical Machine	S-58,520
552	82-074	Dolbeare & Tim Merrill	82/08/09	G	83/09/16	RAL	SAN	Colony Counter	S-58,110
551	82-073	Dolbeare, Frank A.	82/04/27	WD	85/02/05	RAL	SAN	Fluorometric Method of Cell Mutagenesis	S-54,152
714	84-023	Doss, James D.	84/04/04	G	84/09/19	RAL	AL	Electromagnetic field dosimeter	S-60,429
753	84-063	Dow Chemical Co.	84/05/29	P			CH	Water Treatment Chelating Agents	S-59,569
866	85-092	Dow Chemical Co.	84/9/19	G	86/02/20	RAL	CH	Improved Boiler Seal...organic chelant	DE-AC02-79AT34015
203	79-058	Dow Corning Corporation	79/09/10	G	80/01/18	AS	HQ	Solar Silicon	S-52,679
614	83-026	Duracell International	83/02/23	PX	86/02/03	KDI	SAN	Solid State Storage	S-56,333; W-7405-ENG-26
647	83-058	Eaton Corporation	84/06/14	G	85/02/26	RAL	SAN	Elastomeric Storage Systems	S-55,259
648	83-059	Eaton Corporation	84/06/14	G	85/02/26	RAL	SAN	Elastomeric Storage Systems	S-55,184
649	83-060	Eaton Corporation	84/06/14	G	85/02/26	RAL	SAN	Elastomeric Storage Systems	S-55,258
651	83-062	Eaton Corporation	84/06/14	G	85/02/26	RAL	SAN	Elastomeric Storage Systems	S-58,734
652	83-063	Eaton Corporation	84/06/14	G	85/02/26	RAL	SAN	Elastomeric Storage Systems	S-55,186
653	83-064	Eaton Corporation	84/06/14	G	85/02/26	RAL	SAN	Elastomeric Storage Systems	S-55,185
518	82-040	Edwards, David	82/05/25	G	82/07/30	RAL	CH	An Ionization Pressure Gauge	S-56,904
408	81-025	Edwards, David, Jr.	81/02/01	G	82/02/26	RAL	BAO	Helium Leak Detector	S-54,399
409	81-026	Edwards, David, Jr.	81/01/14	G	82/02/26	RAL	BAO	Vapor Pressure Gauge	S-53,141
252	79-106	Eernisse, Errol P.	79/08/15	G	80/07/23	JWG	HQ	Transducers	S-50,154
947	86-064	EG&G Idaho, Inc.	86/06/17	P			CH	At Article Yeilding Ultra-Fine Powder	DE-AC07-76ID-01570; S-65,030
949	86-065	EG&G, Inc.	85/10/08	P			CH	Electronic Imaging System & Techniquee	DE-AC07-76ID01570; S-60,848
950	86-066	EG&G, Inc.	85/10/08	P			CH	Concurrent Ultrasonic Weld Eval. System	DE-AC07-76ID01570; S-61,710
153	79-007	EIC Corporation	79/02/14	WD	80/08/05	RJM	BAO	Energy Storage	S-50,813

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
154	79-008	EIC Corporation	79/02/14	WD	80/08/05	RJM	BAO	Energy Storage	S-50,814
225	79-080	EIC Corporation	79/03/12	WD	79/09/19	KLC	SAN	Fuel Cell Electrolyte	
852	85-079	Eidolonics	85/08/09	CL	85/11/05	RAL	OR	Radiactive or Florscent Substances	S-55,680
858	85-084	Eidolonics	85/09/18	CL	85/11/05	RAL	OR	Radiation Detection System	W-7405-ENG-26
859	85-085	Eidolonics	85/09/18	CL	85/11/05	RAL	OR	Real Time TV Based Paint Image etc.	W-7405-ENG-26
831	85-057	Ellen Raber	85/06/11	G	85/11/18		LLL	Metal Recovery from Brine	S-62,017
774	84-075	Elliott, Guy R.	84/12/17	WD	86/04/24	RAL	AL	Electro Chemical Heat Engine	S-44,774; W-7405-ENG-36
478	81-094	Elliott, Guy R. B.	81/12/02	G	83/06/06	RAL	AL	Liquid Carbon Dio. Extrac. Nat. Res.	S-54,627
157	79-011	Energy Concepts Co.	79/03/01	G	79/08/24	AS	HQ	Oxygen Separation	S-50,214
158	79-012	Energy Concepts Co.	79/03/01	G	79/08/24	AS	HQ	Oxygen Separation	S-50,215
159	79-013	Energy Concepts Co.	79/03/01	G	79/08/24	AS	HQ	Oxygen Separation	S-50,216
160	79-014	Energy Concepts Co.	79/03/01	G	79/08/24	AS	HQ	Oxygen Separation	S-50,217
273	79-121	Energy Materials Corp.	79/11/20	G	80/10/09	MS	HQ	Crystalline Ribbons	NASA NPO-1517
226	79-081	Energy Research Corporation	79/03/13	G	80/08/01	WRM	SAN	Microwave Combustion	S-51,283
462	81-078	Energy Research Corporation	81/10/27	WD	82/03/08	RJM	HQ	Cell Module & Fuel Conditions Dev.	DEN 3-161
464	81-080	Energy Research Corporation	81/10/07	D	82/03/29	KDI	HQ	Stack Compression Leading	S-53,267
465	81-081	Energy Research Corporation	81/10/07	D	82/03/29	KDI	HQ	Electrolyte Filling	S-53,266
466	81-082	Energy Research Corporation	81/10/07	D	82/03/29	KDI	HQ	Cell by Chemical Packaging Means	S-54,119
467	81-083	Energy Research Corporation	81/10/07	D	82/03/29	KDI	HQ	Cell Packaging by Internal Mech. Means	S-55,312
468	81-084	Energy Research Corporation	81/10/07	D	82/03/29	KDI	HQ	Separable Coaling Plate Assembly	S-55,313
485	82-007	Energy Research Corporation	82/02/25	D	83/02/07	KDI	HQ	Recirculating hot fuel cell gases	S-56,118
519	82-041	Energy Research Corporation	82/05/21	D	83/02/07	KDI	HQ	Improved Gas Cooling of Fuel Cells	S-57,018
726	84-036	Energy Research Corporation		G	86/03/18	KDI	HQ	Stack Compression Loading	S-53,267
727	84-037	Energy Research Corporation		G	86/03/18	KDI	HQ	Electrolyte Filling	S-53,266
728	84-038	Energy Research Corporation		G	86/03/18	KDI	HQ	Cell Packaging by Chemical Means	S-54,119
729	84-039	Energy Research Corporation		G	86/03/18	KDI	HQ	Cell Pack./Internal Mechanical Means	S-55,312
730	84-040	Energy Research Corporation		G	86/03/18	KDI	HQ	Separable Cooling Plate Assembly	S-55,313
735	84-045	Energy Research Corporation		G	86/03/18	KDI	HQ	Improved gas cooling of fuel cells	S-57,018
736	84-046	Energy Research Corporation		G	86/03/18	KDI	HQ	Recirculating fuel cell gases	S-56,118
116	78-046	Engelhard Industries	78/12/13	G	80/10/09	RAL	SAN	Matching Current	S-51,537
215	79-070	Engelhard Industries	79/07/09	WD	80/05/26	RAL	CH	CH-115	
497	82-019	Engelhard Industries	82/03/29	G	83/01/11	KDI	CH	Photovoltaics	S-56,914
498	82-020	Engelhard Industries	82/03/29	G	83/01/11	RAL	CH	Photovoltaics	S-54,368
672	83-083	Engelhard Industries	83/08/26	G	84/09/18	RAL	HQ	Phase III, Power Plant Development	
673	83-084	Engelhard Industries	83/10/05	G	84/09/18	RAL	HQ	Phase III, Power Plant Development	
681	83-092	Engelhard Industries	83/11/04	G	84/09/19	RAL	SAN	Fuel Cell Development & Application	S-52,788
682	83-093	Engelhard Industries	83/11/04	G	84/09/18	RAL	SAN	Fuel Cell Development & Application	S-54,594

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
683	83-094	Engelhard Industries	83/11/04	G	84/09/18	RAL	SAN	Fuel Cell Development & Application	S-55,116
684	83-095	Engelhard Industries	83/11/04	G	84/09/18	RAL	SAN	Fuel Cell Development & Application	S-60,055
685	83-096	Engelhard Industries	83/11/08	G	84/09/18	RAL	SAN	Fuel Cell Development & Application	S-60,404
763	83-103	Engelhard Industries		G	84/09/18	RAL	HQ	Film Bonded Fuel Cell Config.	S-56,121
764	83-104	Engelhard Industries		G	84/09/18	RAL	HQ	Fuel Cell/Electrolyte with Wick Feed	S-56,120
765	83-105	Engelhard Industries		G	84/09/18	RAL	HQ	Cooling Assembly for Fuel Cells	S-57,013
766	83-106	Engelhard Industries		G	84/09/18	RAL	HQ	Porous Gas Distribution Plates	S-57,007
767	83-107	Engelhard Industries		G	84/09/18	RAL	HQ	Edge Seal/Porous Gas Dist. Plates	S-57,068
768	83-108	Engelhard Industries		G	84/09/18	RAL	HQ	Supply Electrolyte/Cascade Feed	S-57,069
769	83-109	Engelhard Industries		G	84/09/18	RAL	HQ	Fuel Cell Crimp	S-57,072
770	83-110	Engelhard Industries		G	84/09/18	RAL	HQ	Fuel Cell w/Internal Support	S-57,073
699	84-008	Engelhard Industries	84/01/06	P			CH	Fuel Cell Electric Power	S-59,530
752	84-062	Engelhard Industries	84/01/04	P			CH	Fuel Cell Electric Power Production	S-59,530
77	78-007	Envirogenics Systems Co.	78/02/23	G	80/07/11	JWG	SAN	Gas Separation	S-48,326, S.N. 803,638
253	79-107	Exxon Research & Eng. Co.	79/11/12	CL	81/05/23	WRM	HQ	Gasification Reactor	
264	79-117	Exxon Research & Eng. Co.	79/12/18	G	80/05/09		SAN	Polycrystal.Solar Cells	S-53,660
553	82-075	F.F. Knapp, et al	82/08/10	WD	83/02/16	RAL	OR	Fatty Acids in Nuclear Cardiology	S-58,514
403	81-020	Fisch, Nathanial	81/02/05	WD	83/06/17	RAL	BAO	Sel. Eletron Heating	S-53,193
404	81-021	Fisch, Nathanial	81/02/05	WD	83/06/17	RAL	BAO	Minority Species Heat.	S-54,324
276	80-005	Florida, Univ of	80/02/07	WD/C	81/11/27	JWG	HQ	Platinum Film	S-49,064
267	80-001	Florida, Univ. of	80/01/08	WD/C	81/06/18	WRM	OR	Polymers for Oil Recov.	S-46,815
195	79-050	Foster-Miller Assoc.	79/07/10	WD	80/01/24	RAL	HQ	Material Transport	S-50,483
196	79-051	Foster-Miller Assoc.	79/07/10	WD	80/01/24	RAL	HQ	Material Transport	S-50,484
310	80-038	Foster-Miller Assoc.	80/03/14	CL/C	81/03/18	RAL	AL	Metal Packer	S-53,028
366	80-095	Foster-Miller Assoc.	80/10/24	CL	80/12/01	RAL	AL	Oil Burners	S-53,029
884	86-001	Foster, Christopher A.	85/12/16	P			OR	High Throughput Continuous Cyro-pump	S-63,648; W-7405-ENG-26
347	80-075	Franklin Institute	80/09/25	G	81/11/13	JWG	HQ	DC Motor Control	S-54,120
433	81-049	Franklin Institute	80/09/25	WD	81/06/10	KDI	HQ	Battery Elec. Vehicles	S-54,120
629	83-040	Fresco, Anthony	83/09/02	G	84/05/11	RAL	CH	Compressor	S-59,607
74	78-004	Frumerman Associates	78/06/05	G	80/03/07	RJM	HQ	Pollution-Free Gasif.	S-47,797, Pat. 4,175,929
510	82-032	Fulton, Fred J., et al.	82/02/24	WD	85/02/05	RAL	SAN	Tensile Test Specimens	S-52,716
556	82-078	G.T.E. Laboratories	82/08/19	WD	83/04/10	RAL	CH	Luminescent, etc., and Solar Collector	S-58,255
83	78-013	General Electric Co.	77/05/02	D	78/11/30	MS	HQ	Solar Heating	S.N. 936,626
245	79-100	General Electric Co.	79/10/03	D	81/12/28	JWG	HQ	Air Cooled Combustor	S-47,759
528	82-050	General Electric Co.	82/06/18	G	83/01/31	RAL	AL	Automotive Fuel Cell Power Plant	S-57,896
529	82-051	General Electric Co.	82/06/18	G	83/01/31	RAL	AL	Methanol Reactor Quick Start System	S-57,897
530	82-052	General Electric Co.	82/06/18	G	83/01/31	RAL	AL	Water Vapor Exchange System	S-57,898

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
611	83-023	General Electric Co.	83/04/15	WD	83/11/22	KDI	LLL	Brazing Steam Generator Welds	S-48,298
63	77-024	General Motors	77/05/26	G	78/12/01	NEA	CH	Combustor	S-48,766
64	77-025	General Motors	77/11/11	G	78/12/01	NEA	CH	Turbine	S-49,141
65	77-026	General Motors	77/05/26	G	78/12/01	NEA	CH	Shaft Balancing	S-48,765
200	79-055	General Motors	79/08/16	D	81/03/04	RAL	HQ	Regenerator Seal	
201	79-056	General Motors	79/08/16	D	81/03/04	RAL	HQ	Blade Platform Seal	
302	80-030	General Motors	80/03/26	D	81/02/15	RJM	HQ	Regen. for Seal Design	S-53,251
303	80-031	General Motors	80/03/26	D	81/02/05	RJM	HQ	Ceramic Drive Joint	S-53,253
304	80-032	General Motors	80/03/26	D	81/02/05	RJM	HQ	Shaft Joint	S-53,254
305	80-033	General Motors	80/03/26	D	81/02/05	RJM	HQ	Transition Duets	S-53,256
316	80-044	General Motors	80/04/21	D	81/11/13	KDI	HQ	Seal Mounting	RFP 0064-86
338	80-066	General Motors	80/08/13	D	81/04/20	MS	HQ	Heavy Fuel Combustor	S-54,100
339	80-067	General Motors	80/08/13	D	81/04/20	MS	HQ	Heavy Fuel Combustor	S-54,101
369	80-098	General Motors	80/11/10	D	84/02/15	KDI	HQ	Turbine Fuel System	S-55,300
370	80-099	General Motors	80/11/24	D	83/03/22	KDI	HQ	Ceramic Comb. Mounting	S-53,257
416	81-033	General Motors	81/03/13	D	81/10/28	RJM	HQ	Gas Turbine Rotor	S-55,302
471	81-087	General Motors	81/12/10	D	82/05/28	KDI	HQ	Regenerate Cross Arm Seal Assembly	S-55,305
407	81-024	George, Irwin	81/02/24	G	81/04/20	RAL	AL	"V" Block	S-49,967
1	75-001	Georgetown University	75/02/28	G	75/03/04	RMP	HQ	Thermometer	S-43,400
2	75-002	Georgetown University	75/02/26	G	75/03/04	RMP	HQ	Weapon Detector	S-43,401
270	80-004	Georgia, Univ. of	80/01/24	G	81/11/13	JWG	HQ	Bacteria	S-51,123 & S-51,124
363	80-092	Georgia, Univ. of	80/11/07	G	81/01/22	RAL	HQ	Photogen. Catalysts	
483	82-005	Global Marine Develop. Com.	82/01/19	WD	83/09/13	RAL	SAN	Deploy., Release & Rec. of Ocean Pipes	S-57,367
482	82-004	Global Marine Develop. Inc.	82/01/19	WD	83/09/13	RAL	SAN	Flexible Ocean Upwelling Pipe	S-57,366
505	82-027	Graboski, Michael S.	82/05/25	WD/CW	82/07/12	RAL	CH	Apparatus for Method of Gas. Matters	S-57,147, S.N. 304,736
275	79-123	Grader & Bianchini/U. of CA	79/11/08	G	80/07/11	RJM	SAN	Photovoltaic Cell	S-51,260
924	86-041	Great Lakes Research Corp.	86/06/05	P			OR	Weir Impregnator	S- ;DEN3-369
341	80-069	Grumman Aerospace Corp.	80/08/14	D	81/10/23	RAL	BAO	Solar Cells	S-54,334
343	80-071	Grumman Aerospace Corp.	80/09/03	D	82/06/01	RAL	BAO	Wind Turbine	S-50,837
846	85-073	GTE	85/08/19	G	85/12/26	RAL	AL	Infer Red Flood Light	S-63,499
847	85-074	GTE	85/08/19	G	85/12/26	RAL	AL	Infer Red Flood Light Exteriod Design	S-63,470
823	85-049	GTE Corporation	85/06/25	P			LLL	Efficacy/Fluorescent Lamp	S-63,039; DE-AC03-76SF00098
824	85-050	GTE Corporation	85/06/25	PX	85/11/06		LLL	Improving Fluorescent Lamps	S-62,059; DE-AC03-76SF00098
825	85-051	GTE Corporation	85/06/25	PX	85/11/26	RAL	LLL	Control of Materials in Electric Dischg	S-60,994; DE-AC03-76SF00098
826	85-052	GTE Corporation	85/06/25	PX	85/11/26	RAL	LLL	Photochemical Reactions	S-62,056; DE-AC03-76SF00098
827	85-053	GTE Corporation	85/06/25	PX	85/11/26	RAL	LLL	Preparing Mercury w/Isotopic Distrib	S-62,060; DE-AC03-76SF00098
854	85-080	GTE Corporation	85/06/25	P			SAN	Recovery of Mercury via Electrolytic	S-60,989, S-60,993; 76SF0009

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
678	83-089	GTE Products Corp.	83/10/12	G	85/02/26	RAL	SAN	Dispense mercury from sealed capsules	S-60,090
679	83-090	GTE Products Corp.	83/10/12	G	85/02/26	RAL	SAN	Improve fluorescent lamp efficacy	S-60,901
680	83-091	GTE Products Corp.	83/10/12	G	85/02/26	RAL	SAN	Formation of mercury in capsules	S-60,089
762	84-072	GTE Products Corp.	84/10/29	G	85/02/28	RAL	AL	Infrared Flood Light	S-61,297
777	85-003	GTE Products Corp.	84/09/19	PX	85/03/18	RAL	LLL	Pumping Neodymium Gas	S-60,332
925	86-042	GTE Products Corp.	86/03/07	PW	86/07/24	RAL	LLL	Method/Apparatus Monit. Flow of Mercury	S-62,058; DE-AC03-76SF00098
278	80-007	Gulf & Western	80/01/25	CL	80/03/28	MS	BAO	Coal in Oil Dispersion	S-50,859
279	80-008	Gulf & Western	80/01/25	CL	80/03/28	MS	BAO	Coal in Oil Dispersion	S-50,860
277	80-006	Gulf + Western (Burgess)	80/01/25	G	80/09/05	MS	BAO	Coal in Oil Dispersion	S-50,858
601	83-013	Gulf Res. & Dev. Co.	83/03/16	G	83/03/11	WRM	OR	Strategy For Coal Liquefaction	S-58,045 See W(A)82-042
602	83-014	Gulf Res. & Dev. Co.	83/03/16	G	83/03/11	WRM	OR	Two-Stage Liquefaction Process	S-58,051 See W(A)82-042
603	83-015	Gulf Res. & Dev. Co.	83/03/16	G	83/03/11	WRM	OR	Coal Liquefaction Reaction	S-58,052 See W(A)82-042
450	81-066	H.I. Adler, W.D. Crow	81/07/21	G	83/03/21	RAL	OR	Promoting Growth Anaerobic Bacteria	S-56,534
898	86-015	H.R.I.	85/09/03	G	86/05/19	RAL	CH	Two Stage Direct Liquification of Coal	S-64,107; DE-AC22-83PC60017
656	83-067	Haberl, J., Sedlmayr K.	83/08/15	WD	83/12/02		AL	Improved Design for Concrete Masonry	S-59,861
152	79-006	Hadeishi, T. (U. of CA)	79/02/12	G	79/05/10	RAL	SAN	Discharge Lamp	S-48,401
428	81-044	Hal O. Anger (U. of CA)	81/05/28	G	82/02/18	RAL	SAN	Detector of Radiation	S-54,575
141	78-071	Hall, Fred (Empl/Inv)	78/10/27	CL	80/03/03		SAN	Freewheeling Windmill	S-49,386
142	78-072	Hall, Fred (Empl/Inv)	78/10/27	CL	80/03/03		SAN	Freewheeling Mindmill	S-49,387
143	78-073	Hall, Fred (Empl/Inv)	78/10/27	CL	80/03/03		SAN	HydrogenElectric Power	S-49,388
144	78-074	Hall, Fred (Empl/Inv)	78/10/27	CL	80/03/03		SAN	Neon Refrigeration	S-49,385
161	79-015	Hall, Fred (Stanf. Univ.)	79/03/06	G	79/07/05	RJM	SAN	Solar Collector	S-47,953
7	75-007	Harney, et al. (U. of CA)	75/04/23	G	77/04/25	RMP	SAN	Isotopic Measurer	S-44,283
490	82-012	Harris Corporation	82/03/19	G	83/03/22	RAL	AL	Bias Line Stabilization	S-57,829
491	82-013	Harris Corporation	82/03/19	G	83/03/22	RAL	AL	High Temp. Transdiates & Cur. Mir.	S-57,830
667	83-078	Higgins, Warren W.	84/02/09	WD	84/05/03		AL	Lasing Appartus	S-59,385
301	80-029	Hill, John H.(Univ. of CA)	80/03/20	WD	80/10/09	WRM	SAN	Oxidizer for Diesel	S-53,630
862	85-088	Hirrichs, Curtis Keith	85/07/26	PX	86/07/03	RAL	LL	Transparent Conductive Substrates etc.	S-60,222; DE-AC08-83NV10282
309	80-037	Hodges, Dr. James L. (CE)	80/05/08	G	80/07/11	WRM	SR	Fluidized Bed Reactor	S-52,816
6	75-006	Hoefer Scientific Inst.	74/12/04	WD	77/08/00	RMP	HQ	Control Apparatus	S-43,676
705	84-014	Holcombe, Cressie	84/03/13	CL	84/09/24	RAL	OR	Microwave Coupler	S-60,570
521	82-043	Holcombe, Cressie, et al	82/05/25	G	84/02/12	RAL	OR	Refractory Laminated Comp. Tungsten	S-56,550
511	82-033	Holt, Joseph B.	81/02/19	G	84/10/13	RAL	SAN	Stabilized Beta-Beryllium	S-54,524
147	79-001	Honeywell, Inc.	79/01/08	D	80/08/05	RAL	HQ	Silicon-Coating	
148	79-002	Honeywell, Inc.	79/01/08	D	80/08/05	RAL	HQ	Silicon Growth	
176	79-031	Honeywell, Inc.	79/06/04	D	79/11/16	RAL	HQ	Silicon Solar Cells	
322	80-050	Honeywell, Inc.	80/01/07	D	80/11/01	MS	NV	Laser Optics	S-50,458

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650	83-061	Hoppie, Lyle O.	84/06/14	G	85/02/26	RAL	SAN	Elastomeric Storage Systems	S-60,326
670	83-081	Horowitz, Seymour, et al	83/08/31	G	84/05/16		SAN	Method & Apparatus for Wire Arrays	S-59,460
724	84-034	Hoult, David T.	84/04/09	G	84/08/13	RAL	CH	Gas lubricated piston ring	S-59,691
703	84-012	Hsieh, S.Y.	84/04/16	G	84/05/11	RAL	CH	Fire-Proof Equipment Cabinet	S-59,722
43	77-003	Hughes Aircraft Co.	76/08/18	G	77/04/18	WRM	HQ	Mercury Igniter	S-48,417, S.N. 707,976
863	85-089	Hughes Aircraft Co.	85/07/02	P			LL	Sulfuric Acid Convertor of Heat to Elect	S-63,033; DE-AC03-83SF11942
916	86-033	Hull, Donald, et al	86/04/08	P			AL	Combination Induction Plasma Tube...	S-63,220; W-7405-ENG-36
668	83-079	Hurst, G. S.	83/07/15	G	84/08/17	RAL	OR	Noble Gas Atom Counter	S-60,533
664	83-075	Hurst, G. S., et al	83/09/26	G	86/02/0[illegible]	RAL	OR	Lazur Controlled Sputtering	S-61,110
665	83-076	Hurst, G. S., et al	83/09/26	G	86/02/1[illegible]	RAL	OR	Resonance Ionization Sources	S-60,589; W-7405-ENG-26
449	81-065	Hurst, Payne, Chen	81/07/07	G	82/01/29	RAL	OR	Atoms & Molecules w/ Isotope Sel.	S-55,629
426	81-042	Hydrocarbon Research	81/04/30	G	83/05/05	RAL	OR	Catalyst for Lique.	S-55,658
424	81-040	Hydronautics, Inc.	81/03/12	WD/C	81/03/03	RAL	AL	Drilling System	S-55,549
208	79-063	I.T.E.	79/06/11	G	81/12/29	JWG	BAO	Control Device	S-46,329, 4,034,147
718	84-027	ICRC	84/03/02	CL	85/08/20	RAL	OR	Firing pulverized solvent refined coal	S-60,560
719	84-028	ICRC	84/03/12	CL	85/08/20	RAL	OR	Firing pulverized solvent refined coal	
720	84-029	ICRC	84/04/11	CL	85/08/20	RAL	OR	Corrosion for distallation apparatus	S-60,578
721	84-030	ICRC	84/04/11	CL	85/08/20	RAL	OR	Corrosion for distallation apparatus	S-60,577
361	80-090	Inst. of Gas Tech.	80/10/10	WD/C	81/06/30	RAL	SAN	Energy Input System	S-55,193
362	80-091	Inst. of Gas Tech.	80/10/10	WD/C	81/07/07	RAL	SAN	Advanced Seal System	S-55,194
175	79-030	Instrumentation Res. Tech.	79/05/29	G	79/11/16	RJM	SAN	Neutron Absorption	S.N. 871,759
923	86-040	International Fuel Cells	86/05/05	P			OR	Distortion Resistant Cell Stack in Plate	DE-AC21-79ET15440
37	76-024	International Nickel Co.	76/10/18	G	77/12/29	RMP	BAO	FeTi Alloys	S-47,400
38	76-025	International Nickel Co.	76/10/18	WD	77/12/08	RMP	BAO	FeTi Alloys	S-47,401
51	77-012	InterTechnology Solar Corp.	77/07/14	G	77/09/27	NEA	HQ	Harvesting Algae	S-49,268
472	81-088	Iowa State University	81/08/18	G	82/05/27	RAL	CH	Real Time Speech Format Analyzer & Dis.	S-56,604
476	81-092	Iowa State University	81/12/28	G	82/07/24	RAL	CH	Process of Concen. Ethanol Solutions	S-53,538
569	82-091	Iowa State University	82/09/23	G	83/07/20	RAL	CH		S-55,467
570	82-092	Iowa State University	82/09/23	G	83/07/20	RAL	CH		S-58,696
697	84-006	Iowa State University	83/03/24	G	85/08/13	RAL	CH	Refractive Index & Absorption Detector	S-57,186
698	84-007	Iowa State University	83/04/11	G	85/08/13	RAL	CH	Sulfide Chemiluminescence	S-59,702
943	86-060	Iowa State University	85/06/03	PX	86/08/11	RAL	CH	Forming Magnato Strictive Rods	W-7405-ENG-82; S-62,684
760	84-070	Jatko, W. B., et al	84/09/13	G	86/07/23	RAL	OR	In situ Sensor Identifier	S-61,180
457	81-073	Johns Hopkins University	81/08/24	WD/C	81/11/06	KDI	HQ	Ocean Thermal Energy	S-56,856
31	76-018	Johnson, A. D. (U. of CA)	76/03/14	CL	81/11/05	RAL	SAN	Nitinol Wire	S-44,993
27	76-014	Johnson, A. D. (U. of CA)	76/03/25	G	78/12/19	RAL	SAN	Nitinol Wire	S-44,271
28	76-015	Johnson, A. D. (U. of CA)	75/09/24	G	78/12/29	RAL	SAN	Nitinol Wire	S-44,272

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29	76-016	Johnson, A. D. (U. of CA)	76/02/23	G	78/12/29	RAL	SAN	Nitinol Wire	S-44,910
30	76-017	Johnson, A. D. (U. of CA)	76/03/05	G	78/12/29	RAL	SAN	Nitinol Wire	S-44,970
915	86-032	Johnson, James	86/04/07	P			AL	Shock Induced Hydraulically-Driven Fract	S-63,237; W-7405-ENG-36
132	78-062	Kaiser Aluminum	78/05/23	G	80/09/12		SAN	Cell & Lining Startup	S-49,790
133	78-063	Kaiser Aluminum	78/05/23	G	80/09/12		SAN	Reduction Cells	S-49,791
134	78-064	Kaiser Aluminum	78/05/23	G	80/09/12		SAN	Drained Cathode	S-49,792
135	78-065	Kaiser Aluminum	78/05/23	G	80/09/12		SAN	Cathode Hull Celll	S-49,793
136	78-066	Kaiser Aluminum	78/05/23	G	80/09/12		SAN	Thermal Shock Startup	S-49,794
266	79-119	Kalibjian, R. (Univ. of CA)	79/11/15	G	81/01/22		SAN	Streak/Framing Camera	S-53,464
173	79-028	Kaman Sciences Corp.	79/03/29	D	80/12/01	RJM	HQ	Monitoring	S.N. 738,180
353	80-082	Kaman Sciences Corp.	80/09/03	G	81/04/20	RAL	SAN	Heat Pump	S-55,128
354	80-083	Kaman Sciences Corp.	80/09/03	G	81/04/20	RAL	SAN	Heat Pump	S-55,129
355	80-084	Kaman Sciences Corp.	80/09/03	G	81/04/20	RAL	SAN	Heat Pump	S-55,130
378	80-108	Kaman Sciences Corp.	80/10/20	G	81/04/20	RAL	SAN		S-55,237
379	80-109	Kaman Sciences Corp.	80/10/30	G	81/04/20	RAL	SAN		S-55,238
119	78-049	Kamen Aerospace Corp.	78/12/28	G	79/11/21	RAL	HQ	Turbine Blade	S.N. 921,758
658	83-069	Kehler, Paul	83/08/04	WD	85/12/17	RAL	CH	Triple Channel Analyzer	S-60,603
659	83-070	Kehler, Paul	83/08/04	WD	85/12/17	RAL	CH	Circular Densitometer	S-60,602
797	85-023	Kennecott Corp.	85/06/01	G	86/06/06	RAL	AL	Halogen Gas for Whisker Growth	S-63,487
421	81-038	Kentucky Research Found.	80/12/01	G	81/06/30	RAL	OR	Gasifier Combustor	S-54,834
669	83-080	KMS Fusion, Inc.	83/10/21	G	84/10/16	RAL	SAN	Micro Shell Heat Pipes	S-57,722
778	85-004	KMS Fusion, Inc.	84/10/26	G	85/08/13	RJM	LLL	Inertial Confinement Fusion	S-60,219
686	83-097	KMS Fusion, Inc. (WI-83-080)	83/11/08	CL			SAN	Microshell Heat Pipes	S-57,722
696	84-005	Knapp, F. Jr., et al	83/12/20	WD	85/01/25	RAL	OR	Agent for Eval. of Heart Disease	S-61,155
18	76-005	Knight, B. (Empl/Inv)	76/03/08	CL	78/04/10	RAL	HQ	Laminar Reactor	S-46,636
701	84-010	Koelle, Alfred R.	84/02/02	G	84/06/06	RAL	AL	Interrogation & Detection System	S-47,604
717	84-026	Kramer, S. D., et al	84/04/09	WD	84/08/22	RAL	OR	Phase-sensitive ionization source	S-61,188
722	84-032	Kramer, S. D., et al	84/04/09	WD	84/08/22	RAL	OR	Dual solvent use	S-61,187
921	86-038	Krausse, George J.	86/05/08	WD	86/05/20	RAL	AL	Axial Flow Plasma Shutter	S-63,227; W-7405-ENG-36
920	86-037	Kruse, Herold W.	86/04/28	P			AL	Fiber Optic Converter	S-63,238; W-7405-ENG-36
643	83-054	Lackey, W. J.	83/03/11	D	86/07/23	RJM	OR	Forming Microspheres for Nuc. Waste	S-56,583
700	84-009	Landt, Jeremy A.	84/02/02	G	84/06/06	RAL	AL	Multichannel Gomodyne	S-51,458
712	84-021	Lauf, Robert	84/03/08	PX	86/07/03	RAL	OR	Low temperature alloy	S-61,175; W-7405-ENG-26
796	85-022	Leland Stanford Junior U.		G	85/09/17	RAL	LLL	Thin Solid Film Deposition Method	S-62,717
654	83-065	Leland Stanford U.	83/06/10	G	85/02/26	RAL	SAN	SLAC Microplex Chip	S-59,458
740	84-050	Leland Stanford U.	84/03/01	G	84/10/29	RAL	LLL	Storage integrated circuit	S-60,119
358	80-087	Lembke, John Roger	80/10/20	WD	81/02/00	RAL	AL	Digital Multiflex	S-50,921

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155	79-009	L'Garde, Inc.	79/02/26	CL	79/08/06	RAL	SAN	Packer Concept	S-49,786
463	81-079	LI-CON, Inc.	81/10/28	WD/C	81/12/08	RAL	OR	Bayonet Tube Heat Exchanger	DE-AC05-79CS40290
799	85-025	Lindquist, Lloyd O.	85/06/28	PX	86/07/30	RAL	AL	Measuring Reactivity/Fissile Material	S-57,916;W-7506-ENG-36
218	79-073	Living Systems	79/06/19	G	79/12/21	JWG	AL	Cool Pool Plenum	S-52,100
177	79-032	Lockheed Missiles & Space	79/06/04	G	79/08/24	NEA	SAN	Kinetic Extruder	S-52,254
178	79-033	Lockheed Missiles & Space	79/06/04	G	79/08/24	NEA	SAN	Variable Feedstock	S-52,255
179	79-034	Lockheed Missiles & Space	79/06/04	G	79/08/24	NEA	SAN	Kinetic Extruder	S-52,256
377	80-107	Lockheed Missiles & Space	80/11/24	G	84/04/26	RAL	SAN	Coal Pump	S-52,257
475	81-091	Lockheed Missiles & Space	81/12/28	G	84/04/26	RAL	SAN	Novel Centrifugal Slurry Pump	S-55,927
481	82-003	Lockheed Missiles & Space	82/01/12	G	84/04/26	RAL	SAN	Improve. Kinetic Extruder Pulv. Mat.	S-55,925
616	83-028	Lummus	83/06/03	G	83/07/20	RAL	CH	Coal Liquefaction	S-54,303
617	83-029	Lummus	83/06/03	G	83/07/20	RAL	CH	Coal Liquefaction	S-58,272 See W(I)83-028
618	83-030	Lummus	83/06/03	G	83/07/20	RAL	CH	Coal Liquefaction	S-58,273 See W(I)83-028
619	83-031	Lummus	83/06/03	G	83/07/20	RAL	CH	Coal Liquefaction	S-58,274 See W(I)83-028
620	83-032	Lummus	83/06/03	G	83/07/20	RAL	CH	Coal Liquefaction	S-58,275 See W(I)83-028
621	83-033	Lummus	83/06/03	G	83/07/20	RAL	CH	Coal Liquefaction	S-58,375 See W(I)83-028
622	83-034	Lummus	83/06/03	G	83/07/20	RAL	CH	Coal Liquefaction	S-58,374 See W(I)83-028
623	83-035	Lummus	83/06/03	G	83/07/20	RAL	CH	Coal Liquefaction	S-58,376 See W(I)83-028
194	79-049	Maine, Univ. of	79/04/20	G	79/12/21	JWG	BAO	Furnace	S-51,942
484	82-006	Manahan, Michael P.	82/02/08	G	82/03/18	RAL	CH	Miniaturized Disk Bend Test	S-57,609
165	79-019	Manca, Joseph J. (Empl/Inv)	79/04/09	D	79/06/20	RAL	AL	Coaxial Couplers	S-49,936
166	79-020	Manca, Joseph J. (Empl/Inv)	79/04/09	D	79/06/20	RAL	SAN	Biperiodic Accelerator	S-50,644
205	79-060	Marks Polarized	79/05/14	G	80/08/28	MS	BAO	ETD Cycle	S-50,871
206	79-061	Marks Polarized	79/05/14	CL	80/12/30	RJM	BAO	Power Conversion	S-50,872
207	79-062	Marks Polarized	79/05/14	CL	80/12/30	RJM	BAO	Flow Coupling	S-50,873
209	79-064	Marks Polarized	79/07/24	G	80/08/28	MS	BAO	Generator	S-51,998
212	79-067	Marks Polarized	79/08/13	WD	80/04/18	KLC	BAO	Generator	S-52,003
254	79-108	Marks Polarized Corp.	79/11/19	G	80/08/28	RAL	BAO	Power Conversion	S-50,872
255	79-109	Marks Polarized Corp.	79/11/19	G	80/08/28	RAL	BAO	Flow Coupling	S-50,873
660	83-071	Marling, John B.	83/08/22	G	84/01/30	RAL	LLL	Optical Filter for Atomic Transitions	S-48,929
738	84-048	Martin Marietta	84/06/12	G	85/04/19	RAL	OR	Ductile aluminum alloys	S-61,109
739	84-049	Martin Marietta	84/06/12	G	05/04/19	RAL	OR	Ductile aluminum alloys	S-59,268
787	85-013	Martin Marietta	84/11/26	G	85/04/19	RAL	OR	High-Temp. Alloy	S-61,893
806	85-032	Martin Marietta	84/11/26	P			OR	Dynamic Gas Blazer	S-59,925; DE-AC05-84OR21400
807	85-033	Martin Marietta	84/11/26	P			OR	Clarification Process	S-59,963; DE-AC05-84OR21400
808	85-034	Martin Marietta	84/11/26	WD	85/09/03	RAL	OR	Constant Imperative Oven	S-59,962; DE-AC05-84OR21400
809	85-035	Martin Marietta	84/11/26	P			OR	Advanced Servo Manipulator	S-60,513; DE-AC05-84OR21400

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810	85-036	Martin Marietta	84/11/26	P			OR	Centrifuge Damper Fluids	S-60,595; DE-AC05-84OR21400
811	85-037	Martin Marietta	84/11/26	WD	85/09/11	RAL	OR	Improved Electrolytic All	S-61,184
812	85-038	Martin Marietta	84/11/26	P			OR	Alarm Circuit Optical Interface	S-61,826; DE-AC05-84OR21400
813	85-039	Martin Marietta	84/11/26	PX			OR	Expanding Mandrel	S-59,987; DE-AC05-84OR21400
814	85-040	Martin Marietta	84/11/26	P			OR	Servo Manipulator	S-60,520; DE-AC05-84OR21400
815	85-041	Martin Marietta	84/11/26	P			OR	Pulsed Helium Ionization Detection	S-61,846; DE-AC05-84OR21400
816	85-042	Martin Marietta	84/11/26	P			OR	Extended Range Counting	S-61,834; DE-AC05-84OR21400
817	85-043	Martin Marietta	84/11/26	P			OR	Servo Manipulator, Electromechanical	S-61,896; DE-AC05-84OR21400
818	85-044	Martin Marietta	84/11/26	P			OR	Servo Manipulator, Dual Arm	S-61,874; DE-AC05-84OR21400
819	85-045	Martin Marietta	84/11/26	WD	85/08/20		OR	Improved Radio Luminecent Light	S-61,875; DE-AC05-84OR21400
820	85-046	Martin Marietta	84/11/26	P			OR	Electro Chemical Operation	S-61,848; DE-AC05-84OR21400
821	85-047	Martin Marietta	84/11/26	P			OR	Disposal of High Level Nuclear Waste	S-61,111; DE-AC05-84OR21400
822	85-048	Martin Marietta	84/11/26	P			OR	Charged Particle Detector	S-61,854; DE-AC05-84OR21400
833	85-059	Martin Marietta	85/11/26	P			OR	Fiber Reenforced Ceramic Composites	S-61,153; DE-AC05-84OR21400
834	85-060	Martin Marietta	85/11/26	P			OR	Vapor Deposition	S-61,825; DE-AC05-84OR21400
835	85-061	Martin Marietta	85/11/26	P			OR	Plastic Semiconductor	S-61,853; DE-AC05-84OR21400
836	85-062	Martin Marietta	85/11/26	P			OR	Joining Ceramics to Metals	S-61,894; DE-AC05-84OR21400
837	85-063	Martin Marietta	85/11/26	P			OR	Partially Stabilized Zisconium Fibers	S-58-019; DE-AC05-84OR21400
838	85-064	Martin Marietta	85/04/02	G	86/06/02	RAL	OR	SiC Whisker Composites	S-60,528; DE-AC05-84OR21400
839	85-065	Martin Marietta	85/04/02	P			OR	Metallic Glass Composition	S-61,831; DE-AC05-84OR21400
840	85-066	Martin Marietta	85/04/02	P			OR	Long Range Ordered Alloys	S-61,824; DE-AC05-84OR21400
853	85-067	Martin Marietta	85/11/26	P			OR	Filles Materials	S-62,523/S63,538
841	85-068	Martin Marietta	85/04/02	P			OR	Brazing of Structural Ceramics	S-62,552; DE-AC05-84OR21400
860	85-086	Martin Marietta	85/09/30	P			OR	NiAl and NiFeAl for Oxidizing Env.	S-63,604
885	86-002	Martin Marietta	85/12/30	P			OR	Whole Blood Samples in a Centrifuge...	S-61,810; DE-AC05-84OR21400
886	86-003	Martin Marietta	85/12/27	G	86/06/02	RAL	OR	Cyliumm Carbide Wisker Ceramics	S-63,523; DE-AC05-84OR21400
887	86-004	Martin Marietta	85/12/27	G	86/06/02	RAL	OR	Centering Wisker-reinforced Alumina	S-62,596; DE-AC05-84OR21400
888	86-005	Martin Marietta	85/12/27	P			OR	Radio Pharmaceutical Agent for Brain Ima	S-63,511; DE-AC05-84OR21400
889	86-006	Martin Marietta	85/12/27	P			OR	Heat Pumps Thermal Energy Storage System	S-62,546; DE-AC05-84OR21400
890	86-007	Martin Marietta	85/12/27	P			OR	Vibrational Excitatimal Induced Descrip.	S-62,541; DE-AC05-84OR21400
891	86-008	Martin Marietta	85/12/27	P			OR	Surface Enhanced Riman Spectropy	S-61,868; DE-AC05-84OR21400
892	86-009	Martin Marietta	85/12/27	P			OR	Radioiodentdle Iodoriyale Methyl-teranc.	S-62,539; DE-AC05-84OR21400
893	86-010	Martin Marietta	85/12/27	P			OR	Improved Gas Hydrodrate Coal Storage Sys	S-61,832; DE-AC05-84OR21400
894	86-011	Martin Marietta	85/12/27	P			OR	Improved Asmium-191-eridem-191 Radionucl	S-61,155; DE-AC05-84OR21400
926	86-043	Martin Marietta	86/05/19	P			OR	High Productivity Biacatalyst Beads	S-62,550; DE-AC05-84OR214000
927	86-044	Martin Marietta	86/05/19	P			OR	Architecture for Production Rule Systems	S-63,610; DE-AC05-84OR214000
928	86-045	Martin Marietta	86/05/19	PZ	86/08/07	RAL	OR	...Tensile Testing Apparatus	S-63,520; DE-AC05-84OR214000

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929	86-046	Martin Marietta	86/05/19	P			OR	Closed-Loop Pulsed Helium Ionization Det	S-63,613; DE-AC05-84OR214000
930	86-047	Martin Marietta	86/05/19	P			OR	Lead Phosphate Glass Composition-Optical	S-63,618; DE-AC05-84OR214000
931	86-048	Martin Marietta	86/05/19	P			OR	Triple Effect Absorption Chiller 2 Refri	S-63,645; DE-AC05-84OR214000
932	86-049	Martin Marietta	86/05/19	P			OR	Zirconia-bonded Zirconia/Metal Oxide Fib	S-63,640; DE-AC05-84OR214000
933	86-050	Martin Marietta	86/05/19	P			OR	Alignment Device Coupling Optical Fibers	S-63,654; DE-AC05-84OR214000
934	86-051	Martin Marietta	86/05/19	P			OR	Biocatalyst Beads Incorporated Absorbent	S-63,665; DE-AC05-84OR214000
935	86-052	Martin Marietta	86/05/19	P			OR	Anaerobic Biocatalyst Beads	S-63,668; DE-AC05-84OR214000
936	86-053	Martin Marietta	86/05/19	P			OR	Radiohalogenated Branched Carbohydrates	S-63,679; DE-AC05-84OR214000
937	86-054	Martin Marietta	86/05/19	P			OR	Advanced System-Prod. Biocatalyst Beads	S-63,677; DE-AC05-84OR214000
938	86-055	Martin Marietta	86/05/19	P			OR	Rotor/Disk Syst. Auto. Proc. Whole Blood	S-63,682; DE-AC05-84OR214000
939	86-056	Martin Marietta	86/05/19	P			OR	Absorption Heat Pump-2 Refriger. Circuit	S-63,687; DE-AC05-84OR214000
216	79-071	Mathematical Sciences	79/02/15	CL	80/00/00		AL	Laser Development	EY-77-C-04-3868
489	82-011	Maurice A. White, et al.	82/03/08	G	82/07/29	RAL	HQ	Hydraulic Output for 15 KW Stir. Engine	DEN 3-212
900	86-017	McCulloch, R. W.	86/01/23	P			OR	Integrated Heat Generating & Sensing Sys	S-62,525
901	86-018	McCulloch, R. W.	86/01/23	P			OR	Segmented Heater Cable	S-62,581
323	80-051	McDonnell Douglas Corp.	80/06/30	WD	81/11/13	RAL	AL	Wind Turbine	S-53,078
324	80-052	McDonnell Douglas Corp.	80/06/30	WD	81/11/13	RAL	AL	Wind Turbine	S-53,079
423	81-039	McEvilly, Thomas (U. of CA)	81/03/26	G	81/12/29	RAL	SAN	Auto. Seismic Proc.	S-54,587
543	82-065	McGraw-Edison	82/07/22	G	83/07/20	RAL	CH	Gear Transmission	S-58,609
544	82-066	McGraw-Edison	82/07/22	G	83/07/20	RAL	CH	Equalizing Seal Assembly	S-58,610
545	82-067	McGraw-Edison	82/07/22	G	83/07/20	RAL	CH	Lubrication System	S-58,611
546	82-068	McGraw-Edison	82/07/22	G	83/07/20	RAL	CH	Bearing Mounting	S-58,612
547	82-069	McGraw-Edison	82/07/22	G	83/07/20	RAL	CH	Split Seal Assembly	S-58,613
364	80-093	McLellan, Edward J.	80/11/10	WD	81/07/08	RAL	AL	Ionization of Gases	S-52,479
458	81-074	McLellan, Edward J.	81/09/17	G	82/02/24	RAL	AL	Ionization of Gases	S-52,479
115	78-045	Mechanical Technology, Inc.	78/11/07	G	79/11/21	RAL	HQ	Surface Coating	S-51,537
289	80-018	Mechanical Technology, Inc.	80/02/29	G	83/03/18	RAL	OR	Hermetric Turbine Gen.	S-54,000
332	80-060	Mechanical Technology, Inc.	80/07/10	WD	82/03/11	RAL	HQ	Stirling Engine	S-57,012
333	80-061	Mechanical Technology, Inc.	80/07/10	G	82/07/29	RAL	HQ	Solar Stirling Engine	S-57,011
447	81-063	Mechanical Technology, Inc.	81/05/14	G	82/07/24		RAL	BAO Adjustable Clearance Seal	S-56,902
917	86-034	Mechanical Technology, Inc.	86/04/15	P			OR	External, Tubed Vibration Absorber-HAHP	86X-47985V
50	77-011	Mechanics Research, Inc.	76/10/06	G	78/11/09	WRM	SAN	Well Logging	S-47,976
104	78-034	Mechanics Research, Inc.	76/10/06	G	78/11/09	WRM	SAN	Well Logging	S-48,343
118	78-048	Mechanics Research, Inc.	76/10/06	G	79/04/06	WRM	SAN	Well Sondes	S-48,344
78	78-008	Merix Corporation	77/10/04	G	78/10/01	NEA	BAO	Crude Distillation	S-48,878
5	75-005	Metz, H. S. (Empl/Inv)	75/01/30	G	75/08/05	RMP	HQ	Two-Phase Flow Meter	
285	80-014	Metz, Philip D.	80/02/07	G	81/01/29	MS	BAO	Couplings	S-51,974

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73	82-095	Metz, Phillip D.	82/10/04	G	83/03/18	RAL	CH	Heat Storage Tank	S-54,390
97	79-052	Michigan Tech. Univ./Babcock	78/11/09	D	80/08/29	RAL	HQ	Lignite Drying	S.N. 082,666
61	84-071	Midwest Research Inst.	84/10/23	P			CH	Tracking System for Solar Collector	S-51,751
62	79-016	Milleron, Norman (U. of CA)	79/03/06	G	79/11/21	RJM	SAN	Molecular Pump	S-36,851
63	79-017	Milleron, Norman (U. of CA)	79/03/06	G	79/11/21	RJM	SAN	Rotating Accelerator	S-37,499
64	79-018	Milleron, Norman (U. of CA)	79/03/06	G	79/11/21	RJM	SAN	Heavy Ions	S-38,724
19	77-010	Minnesota, Univ. of	77/06/20	CL	78/04/04	NEA	HQ	Study of a Substance	S-49,299
3	77-014	Minnesota, Univ. of	77/07/18	D	79/03/23	RJM	CH	Isotope Separation	S-48,737, S.N. 798,624
313	80-041	Minnick, John L.	79/11/21	G	80/08/21	JWG	CH	Scrubber Sludge	S-53,504
314	80-042	Minnick, John L.	79/11/21	G	80/08/21	JWG	CH	Cementitious Comp.	S-53,505
315	80-043	Minnick, John L.	79/11/21	WD/C	81/08/06	JWG	CH	Combustion Wastes	S-53,822
36	76-023	Missouri, Univ. of	76/10/13	G	77/06/14	RMP	CH	Hydraulic Jet Nozzle	S-47,022
58	77-019	Missouri, Univ. of	77/07/15	G	77/12/22	NEA	CH	Drilling Device	S-48,190
111	78-041	Missouri, Univ. of	79/01/31	G	80/05/16	RAL	HQ	Cutting Head	S-50,179
54	77-015	MIT	77/06/10	G	77/02/22	RJM	BAO	Cooling Tower	S-47,427, S.N. 714,557
38	78-018	MIT	78/06/20	G	79/08/31	NEA	HQ	Magnetite Recovery	S-50,187
114	78-044	MIT	78/08/12	G	79/02/16	RMP	BAO	Cross-Field Device	S-46,972, S.N. 776,392
170	79-024	MIT	79/05/18	G	79/10/20	AS	HQ	Generator for Gallium	S-51,987
171	79-025	MIT	79/05/18	G	79/10/20	AS	HQ	Radiopharmaceutical	S-51,988
172	79-026	MIT	79/05/18	G	79/10/20	AS	HQ	Generator for Gallium	S-51,989
174	79-029	MIT	79/05/18	CL	80/10/07	RAL	HQ	Solar Cells	S.N. 756,358
210	79-065	MIT	79/08/03	WD	80/11/14		BAO	Energy Storage System	S-51,995
293	80-022	MIT	80/01/21	WD/CW	83/05/09	RAL	BAO	Wire Mesh	S-53,173
297	80-025	MIT	80/03/11	WD/C	81/04/08	MS	BAO	Mutagenesis	S-53,178
298	80-026	MIT	80/01/21	CL	80/11/17	MS	BAO	Ionized Gammaray Cham.	S-53,173
340	80-068	MIT	80/07/30	WD/C	81/10/06	RAL	BAO	Infrared Miscroscope	S-54,332
374	80-103	MIT	80/11/10	WD	80/12/17	RAL	BAO	Niobium-Aluminum Comp.	S-54,379
398	81-014	MIT	81/02/04	WD	82/12/01	KDI	HQ	Auto. Switching Matrix	S.N. 117,706
399	81-015	MIT	81/02/03	WD/C	81/06/05	MS	HQ	Sheet Metal Forming	
139	78-069	Monosolar, Inc.	78/10/23	WD	80/08/04	KLC	SAN	Compound Semiconductors	S-51,292
568	82-090	Monsanto Co. (Mound)	82/07/19	WD	86/04/09	RJM	AL	Microen Capsulation of Fine Solids	S-50,918; DE-AC04-76DP00053
62	77-023	Monsanto Research Corp.	77/06/22	D	79/02/02	RJM	HQ	Polymer	S.N. 784,488
127	78-057	Montana State Univ.	78/06/13	WD	79/08/03	WRM	NV	NOx Control	S-46,695
295	80-024	Morrell, Roger J., DOI	80/03/10	CL	80/05/13	JWG	HQ	Backreamer	S.N. 551,183
9	75-009	Morrison, R. L.	75/09/09	CL	77/09/15	RMP	HQ	Gas Chromatography	S-44,961
895	86-012	Mossman, C. A. etal	86/01/09	P			OR	Cable Recognition Circuit	S-59,299; W-7405-ENG-26
896	86-013	Mossman, C. A. etal	86/01/09	P			OR	Cable Recognition Circuit	S-59,257; W-7405-ENG-26

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562	82-084	Mountain States Energy, Inc.	82/08/31	G	83/07/15	RAL	CH	Solids Supply Metering System	S-57,699
879	85-105	MW Kellogg Company	85/12/04	P			OR	Circulating Fluid Bed Combustion	S-62,562;S-63,565 - S-63,568
509	82-031	National Coal Board	82/04/24	CL	83/05/12	KDI	HQ	Rotary Seals	DE-AC01-78ET13339
899	86-016	Neeper, Donald A.	86/01/29	WD	86/03/31	RAL	AL	Apparatus Downward Transpart of Heat	S-62,254; W-7405-ENG-36
655	83-066	Neff, Julie J.	83/11/15	G	83/10/31	RAL	AL	Heat Transfer Device	S-59,818
34	76-021	New York, City Univ. of	76/09/03	G	77/04/18	WRM	SAN	Infrared Laser	S-47,396
420	81-037	Newport News Shipbuilding	81/03/12	WD	85/01/25	RJM	HQ	Steam Drains	
578	82-100	NL Industries, Inc.	82/12/21	G	84/05/11	RAL	AL	Rheometer Torque Sensor	S-58,830
579	82-101	NL Industries, Inc.	82/12/21	G	83/12/12	RAL	AL	Diffusion Shield for Gas	S-58,831
580	82-102	NL Industries, Inc.	82/12/21	G	83/05/11	RAL	AL	Holder for Easily Removable Elec.	S-58,832
581	82-103	NL Industries, Inc.	82/12/21	G	83/05/11	RAL	AL	Filtration Rate Monitor	S-58,833
469	81-085	North Wind Power Co.	81/11/10	WD/C	81/11/09	JWG	HQ	Small Wind Energy Conversion Systems	S-57,803/S-57,804
538	82-060	Northern Res. & Eng. Co.	82/06/01	G	84/09/31	RAL	SAN	Splineless Coupling Means	S-54,557
401	81-018	Northrup/ARCO	81/02/13	G	81/04/20	RAL	AL	Heliostat Control	S-55,509
402	81-019	Northrup/ARCO	81/02/13	G	81/04/20	RAL	AL	Heliostat Structure	S-55,511
260	79-114	NSF/Sponsored Grant/SERI	79/10/12	CL	80/04/17	WRM	CH	Solar Absorber Film	
851	85-078	Oak Ridge Associated Univ.	85/08/14	P		RAL	OR	1-alkyl-2-acetyl-sn-glycerol	S-60,597
948	85-110	Oak Ridge Associated Univ.		G	85/10/02	RAL	OR	Alkylacetoylalycerophosphocholine	DE-AC05-76OR00033; S-55,631
19	76-006	Occidental Research Corp.	76/03/22	CL	79/05/26	RMP	HQ	Flash Pyrolysis	
103	78-033	Occidental Research Corp.	77/07/08	G	80/08/27	JWG	SAN	Heat Exchange	S-48,970 & 48,971
128	78-058	Occidental Research Corp.	78/03/31	G	80/11/15		SAN	Pyrolsis Reactor	S-49,754
229	79-084	Occidental Research Corp.	79/04/30	G	81/04/20	RAL	SAN	Pyrolsis Reactor	S-52,294
230	79-085	Occidental Research Corp.	79/04/30	G	81/04/20	RAL	SAN	Energy Form	S-50,572
583	82-105	Oklahoma, Univ. of	82/12/27	CL/CW	83/02/22	RAL	SAN	Biosurfactant in Enhanced Oil Recov.	S-59,456
626	83-037	Olin Corporation	83/06/01	G	83/11/03	RAL	AL	Non-Aqueous Pruification	S-58,888
627	83-038	Olin Corporation	83/06/01	G	83/11/03	RAL	AL	Aqueous Removal of Metal Contaminants	S-58,889
628	83-039	Olin Corporation	83/06/01	G	83/11/03	RAL	AL	Removal of Impurities from Molten	S-58,890
21	76-008	Origo, Inc.	76/04/05	CL	76/12/31	RMP	HQ	Streak Camera Tube	S-44,788
35	76-022	Parsons, Ralph M., (Malek)	76/09/07	G	79/01/05	RMP	SAN	Fuel from Coal	S-45,872 & S-47,917
588	82-110	Perje Skotheim		WD	83/12/12		CH	Photocell	S-58,690
911	86-028	Perry, Robert A.	86/03/17	G	86/06/18	RAL	AL	Rapid Reduction of Nitric Oxide	S-63,411; DE-AC04-76DP00789
914	86-031	Petranto, Joseph J.	86/04/07	P			AL	Improved Split Gland	S-62,239; W-7405-ENG-36
283	80-012	Phillips, Alan G.	80/02/05	G	80/09/05	JWG	AL	Rare Earth Oxides	S-52,085
325	80-053	Phrasor Scientific, Inc.	80/05/19	G	80/09/05	RAL	CH	Polycrystalline Silicon	XS-9-8041-5
16	76-003	Pierce, R. C. (Empl/Inv)	75/10/06	D	77/05/20	RMP	BAO	Evaporator Probe	S-46,311
80	78-010	Pittsburgh & Midway	77/11/15	G	80/07/30	WRM	OR	Metal Filtration	S-49,440
89	78-019	Pittsburgh & Midway	77/11/15	G	80/07/30	WRM	OR	Slurry Recycle Scheme	S-49,441

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90	78-020	Pittsburgh & Midway	77/11/15	G	80/07/30	WRM	OR	Filter Screen	S-49,442
91	78-021	Pittsburgh & Midway	78/01/10	G	80/07/30	WRM	OR	Coal Liquefaction	S-49,448
92	78-022	Pittsburgh & Midway	78/01/11	G	80/07/30	WRM	OR	Coal Liquefacation	S-49,449
93	78-023	Pittsburgh & Midway	78/01/11	G	80/07/30	WRM	OR	Filtration of Coal Liq.	S-49,450
94	78-024	Pittsburgh & Midway	78/03/16	G	80/07/30	WRM	OR	Drying Settler Resider	S-49,495
95	78-025	Pittsburgh & Midway	78/05/16	G	80/07/30	WRM	OR	SRC Process	S-50,138
96	78-026	Pittsburgh & Midway	78/05/16	G	80/07/30	WRM	OR	Coal Reactivity	S-50,139
97	78-027	Pittsburgh & Midway	78/06/01	G	80/07/30	WRM	OR	Granul. of SRC Fines	S-50,142
110	78-040	Pittsburgh & Midway	78/10/05	G	80/06/30	WRM	OR	Plug Mill Extruder	S-50,887
168	79-022	Pittsburgh & Midway	79/04/29	G	80/07/30	WRM	OR	SRC Process	S-52,034/S-52,072
130	78-060	Pontius, John F. (Bechtel)	78/05/02	D	80/08/17	WRM	SAN	Pipe Support Clamp	S-48,247
257	79-111	Power Technologies Inc.	79/11/07	G	80/07/11	RAL	BAO	Autotransformer	S-52,004
785	85-011	Princeton University	85/03/07	P			CH	X-ray Laser Target	S-62,692
786	85-012	Princeton University	85/03/04	PW	85/05/07	RAL	CH	X-ray Laser	S-61,312
790	85-016	Princeton University	85/03/07	P			CH	Lasers	S-62,900
791	85-017	Princeton University	85/03/07	PX	85/05/?	RAL	CH	Lasers	S-62,902
60	77-021	Purdue Research Foundation	77/09/29	CL	81/01/23	RAL	HQ	Cellulosic Materials	S-49,259
244	79-099	Q-Dot	79/09/10	G	80/11/03	JWG	NV	Data Recorder	S-44,061 & S-44,078
435	81-051	R. K. Stump (U.of CA)	81/05/20	C	83/08/22	RAL	SAN	Ionization Chamber	S-55,961
593	83-005	Rad. Monitoring Dev., Inc.	82/11/04	G	80/11/17		CH	Thin-Films I Spray Pyrolysis	S-59,560
594	83-006	Rad. Monitoring Dev., Inc.	82/11/04	G	80/11/17	RAL	CH	Thin-Film I Spray Pyrolysis	S-59,561
595	83-007	Rad. Monitoring Dev., Inc.	82/11/04	G	80/11/17	RAL	CH	Method for Thin Films I Spray Pyrolysis	S-59,562
360	80-089	Radiation Monitoring	80/08/15	G	80/11/17	RAL	CH	Solar Cells	S-54,932
671	83-082	Rappaport, Stephen, et al	83/06/16	G	85/04/16	RAL	SAN	Monitor for determining formaldehyde	S-55,989
117	78-047	RCA Corp.	78/10/23	G	79/04/06	NEA	AL	Solar Drier	S-50,916
202	79-057	RCA Corp.	79/08/15	G	80/05/09	RAL	HQ	Sprayable Titanium	JPL 954868
375	80-104	RCA Corp.	80/11/25	D	81/12/04	KDI	HQ	Silicon Solar Array	
380	80-110	RCA Corp.	80/12/02	D	81/12/04	KDI	HQ	Solar Array	
460	81-076	RCA Corp.	81/10/06	G	82/05/27	RAL	CH	Thin-Film Polycry. Photovoltaic Devices	Sub. XS-0-9100-3
561	82-083	Reedy, Gerald	82/09/14	D	83/04/20	RJM	CH	Cryogenic Collection & Analysis	S-47,076
675	83-086	Reedy, Gerald T.	83/11/03	G	84/01/30		CH	Device for collecting matric samples	S-47,076
676	83-087	Reedy, Gerald T.	83/11/03	G	84/01/30		CH	Gas Chromotography/matrix isolation	S-51,030
677	83-088	Reedy, Gerald T.	83/11/03	G	84/01/30		CH	Matrix isolation infrared spectrometry	S-53,570
907	86-024	Reedy, Gerald T.	86/02/26	G	86/05/27	RAL	CH	Resistance Photoresist Metric Isolation	S-62,659; W31-109-ENG-38
577	82-099	Reg. of U of CA/Somorjai	82/10/21	G	84/12/18	RAL	SAN	Elec. Photodissociation of Chemicals	S-59,032
582	82-104	Reg. of U. of CA	82/11/29	G	85/06/12	RAL	AL	Inductively Stabilized Electrodes	S-58,434
741	84-051	Reg. of U. of CA	84/06/13	G	85/02/25	RAL	LLL	Integrating temperature microsensor	S-60,965

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742	84-052	Reg. of U. of CA	84/06/13	WD	84/08/06	RAL	LLL	Piezoelectric sorption detection	S-60,375
586	82-108	Reg. of U. of CA (Roose)	82/12/17	G	83/04/05	RAL	AL	Multi-Lead Heat Sink	S-58,407
776	85-002	Reg. U. of CA	84/10/19	G	85/04/10	RAL	LLL	Optrode/Sensing Nydrocarbons	S-62,029
311	80-039	Research Corporation	80/05/13	WD/C	81/02/03	MS	HQ	Cement	EY-76-C-02-0016
419	81-036	Research Triangle Inst.	81/03/03	WD/C	81/12/08	RAL	OR	Solar Cells	S-55,671
754	84-064	Research-Cottrell Corp.	84/01/31	G	86/07/03	RAL	CH	Pollution Control	S-59,577
10	75-010	Riley, J. F. (Ansul)	77/01/17	D	78/01/09	RAL	SAN	Fire Extinguisher	S-44,968
596	83-008	Robert J. Lauf, et al	82/12/08	G	84/08/31	RAL	OR	Microwave Mode Filter	S-59,231
597	83-009	Robert J. Lauf, et al	82/12/08	G	84/08/31	RAL	OR	Manu. a Microwave Mode Filter	S-59,232
250	79-105	Rockefeller Univ.	79/11/16	G	80/07/30	MS	HQ	Particle Interactions	S-54,322, S.N. 127,042
138	78-068	Rocket Research Company	78/09/25	D	80/11/18	KLC	SAN	Energy Storage System	S-50,508
198	79-053	Rocket Research Company	78/07/24	G	79/11/17	JWG	RL	Explosive	S-49,559
590	83-002	Rocket Research Company	83/01/21	G	83/04/19	RAL	CH	Ambient Storage Tank	S-53,239 See W(I)78-068
591	83-003	Rocket Research Company	83/01/21	G	83/04/19	RAL	CH	Industrial Chemical Storage Tank	S-55,881 See W(I)78-068
496	82-018	Rocket Research Corporation	82/03/29	CL		RAL	CH	Catalyst	S-55,881
70	77-031	Rocketdyne	77/06/23	D	80/09/05	WRM	SAN	Hydrogeneration	S-48,952, S.N. 887,566
842	85-069	Rockwell International	85/07/11	PX	86/08/04	RAL	LLL	Separation Uranium-Magnesium Flouride	S-62,797; DE-AT03-83SF11948
844	85-071	Rockwell International	85/07/11	PX	86/08/04	RAL	LLL	Decontamination of Magnesium Flouride	S-62,079; DE-AT03-83SF11948
140	78-070	Rockwell Intl. Corp.	78/10/21	G	80/08/27	KLC	SAN	Nuclear Reactor Valve	S-49,717
248	79-103	Rockwell Intl. Corp.	79/08/15	G	81/02/11	JWG	SAN	Sodium Purification	S-47,366
356	80-085	Rockwell Intl. Corp.	80/10/20	G	81/02/04	RAL	AL	Photovoltaic	S-54,471
368	80-097	Rockwell Intl. Corp.	80/06/23	G	84/10/31	RAL	SAN	Nuclear Reactor Plug	S-53,401
775	85-001	Rockwell Intl. Corp.	84/09/11	P			LLL	Non-Oxide Silicon Compounds	S-62,701; DE-AC03-78ER01885
798	85-024	Rockwell Intl. Corp.	85/06/24	P			OR	Gasification of Black Liquor	S-62,565; DE-AC05-80CS40341
359	80-088	Rockwell Intl./Energy Syst.	80/10/29	D	81/08/18	RAL	RL	Emergency Core Cooling	S-53,201
286	80-015	Rockwell Intl./Rocketdyne	80/02/14	G	83/12/30	RAL	SAN	Level Sensor	EF-77-01-2612
396	81-012	Rockwell Intl./Rocketdyne	81/01/07	G	83/07/20	RAL	AL	Flywheel Shell	S-54,215
397	81-013	Rockwell Intl./Rocketdyne	81/01/07	G	83/07/20	RAL	AL	Fiber Comp. Rim	S-54,216
410	81-027	Rockwell Intl./Rocketdyne	81/03/05	G	82/01/26	RAL	AL	Downhole Steam Gen.	S-55,224, S.N. 202,991
400	81-016	Rockwell/FMC Corp.	81/01/15	WD	84/05/31	RAL	SAN	Oil Squeeze/Bearing Ct.	S-55,210
427	81-043	Roger C. Carr (U of CA)	81/05/28	G	81/05/18	RAL	SAN	Improved Soption Pump	S-54,515
513	82-035	Rohrer, John Smith	82/06/01	G	83/06/24	RAL	NV	Parametric Capacitor	S-54,714
211	79-066	Rose, Max J./AUI	79/08/08	D	80/10/09	MS	BAO	Alternate Liq. Fueld	S-49,898, S.N. 886,380
14	76-001	Rueth, John A. (Empl/Inv)	76/01/15	G	76/04/20	RMP	AL	Poppet Valve	S-45,081
517	82-039	Russell Dietz (BNL)	82/06/02	D	83/01/07	RAL	CH	Perfluorocarbon Tracer System	S-58,237
15	76-002	Russo, A. J.	76/02/04	CL	78/10/11	RAL	HQ	Heat Exchanger	S-45,051
451	81-067	Rust Engineering Co.	81/07/24	WD	82/11/03	KDI	HQ	Biomass Liquefaction Project	

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
674	83-085	Salzman, Gary C.	84/04/18	WD	84/09/06		AL	Optically active biological particle	S-56,269
869	85-095	Sandia Corp	85/11/13	P			AL	Strained Layer Superlattice Technology	S-59,815 DE-AC0476DP00789
865	85-091	Sandia Corp.	85/11/13	P			AL	Strained-Layer Superlattice Technology	S-56,737; DE-AC04-76DP00789
867	85-093	Sandia Corp.	85/11/13	P			AL	Strained Layer Superlattice Technology	S-58,874 DE-AC0476-DP00789
868	85-094	Sandia Corp.	85/11/13	P			AL	Strained Layer Superlattice Technology	S-59,800 - DE-AC0476DP00789
870	85-096	Sandia Corp.	85/11/13	P			AL	Strained Layer Superlattice Technology	S-61,210 DE-AC0476DP00789
871	85-097	Sandia Corp.	85/11/13	P			AL	Strained Layer Superlattice Technology	S-61,253 DE-AC0476DP00789
802	85-028	Sandia Corporation	85/06/27	WD	86/07/02	RAL	AL	Polysilane Positive Photoresist	S-57,890; DE-AC04-76DP00789
803	85-029	Sandia Corporation	85/06/27	WD	86/02/28	RAL	AL	Rapid Reduction/Nitric Oxide	S-63,411; DE-AC04-76DP00789
849	85-076	Sandia National Laboratory	85/08/21	WD	86/02/28	RAL	AL	Poly Photo Resists/use in Deep UV	S-62,439; DE-AC04-76DP00789
850	85-077	Sandia National Laboratory	85/08/21	WD	86/02/28	RAL	AL	Improved methods/Synthesis Poly Silanes	S-63,429; DE-AC04-76DP00789
342	80-070	Schneider, M. D.	80/07/28	G	80/07/30	RJM	OR	Collagenous Biomaterial	S-50,770
185	79-040	Schneider, M. D. (Empl/Inv)	79/06/13	G	80/07/30	RJM	OR	Platelet Aggregation	S-49,992, S.N. 875,730
23	76-010	Schow, O. E. (Empl/Inv)	76/04/09	G	76/08/17	RMP	OR	Leak Detector	S-47,152
149	79-003	Science Applns., Inc.	79/01/17	CL	79/04/25	RMP	OR	Recycle	S-48,318
640		SEE W(I)83-041		G	84/05/25	RAL	OR	Heat Pump	S-54,821
76	78-006	Sensor Technology	78/01/23	G	80/07/10	JWG	HQ	Solar Power Panel	S.N. 709,415
587	82-109	SERI (Danninger)	83/01/26	G	83/04/12	RAL	CH	Tiltable Table for Optical, etc.	S-53,853
269	80-003	Shaffer NY Univ.	80/01/18	WD	81/06/09	RJM	BAO	Combustion Head	S-52,012
795	85-021	Sherman, Max H.		G	86/03/11	RAL	LLL	Measure Building Leakage	S-62,074
39	76-026	Silva, Frank A. (Empl/Inv)	76/10/06	CL	78/10/14	RMP	HQ	Cable Shield Adapter	S-47,425
946	86-063	Singh, Suman P.N.	86/06/27	P			OR	Side Window Defogger/Deminster for Auto.	S-64,929; DE-AC05-84OR21400
737	84-047	Siomos, Konstadinos	84/06/05	P			OR	Liquid Phase Multiphoton	S-61,820
66	77-027	Smith et al. (U. of CA)	77/03/30	G	79/06/11	NEA	SAN	Enzyme Analysis	S-47,351
121	78-051	Smith et al. (U. of CA)	78/10/03	G	79/06/11	NEA	SAN	Enzyme Assay	S-49,741
331	80-059	Smithwick/Smyrl	80/02/27	G	83/03/21	RAL	OR	Amine Derivative	S-52,912
247	79-102	SOL/LOS, Inc.	79/10/24	G	80/05/02	RAL	HQ	Silicon Solar Cells	NASA
100	78-030	Solar Energy Tech., Inc.	78/06/06	G	79/03/08	NEA	BAO	Rod Collector	S-49,674
101	78-031	Solar Energy Tech., Inc.	78/06/06	G	79/03/08	NEA	BAO	Solar Concentrators	S-49,675
506	82-028	Solar Turbines, Internationl	82/04/22	CL	83/05/12	KDI	CH	Solar Heat Exchanger Metal Heat Pumps	S-57,645, W(A)81-011
106	78-036	Southwest Research Inst.	78/04/06	G	79/07/13	NEA	OR	Temperature Measurement	S-49,985
107	78-037	Southwest Research Inst.	78/04/06	G	79/07/13	NEA	OR	Temperature Sensor	S-49,986
108	78-038	Southwest Research Inst.	78/04/06	G	79/07/13	NEA	OR	Optical Fiber	S-49,990
109	78-039	Southwest Research Inst.	78/08/23	G	79/07/13	NEA	OR	Remote Sensing	S-49,991
499	82-021	Southwest Research Inst.	82/02/24	CL/CW	82/04/30	RAL	SAN	Production of Lime	S-57,350
500	82-022	Southwest Research Inst.	82/02/24	CL/CW	82/04/30	RAL	SAN	Production of Lime	S-57,360
501	82-023	Southwest Research Inst.	82/02/24	CL/CW	82/04/30	RAL	SAN	Production of Lime	S-57,361

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
82	78-012	Spectro-Systems Corp.	78/05/15	G	79/05/04	RAL	HQ	Temperature Sensors	S-50,201
180	79-035	Spectro-Systems Corp.	78/05/15	G	79/05/04	RAL	HQ	Temperature Measurement	S-50,202
181	79-036	Spectro-Systems Corp.	78/05/15	G	79/05/04	RAL	HQ	Temperature Measurement	S-50,203
182	79-037	Spectro-Systems Corp.	78/05/15	G	79/05/04	RAL	HQ	Temperature Measurement	S-50,204
183	79-038	Spectro-Systems Corp.	78/05/15	G	79/05/04	RAL	HQ	Temperature Measurement	S-50,205
184	79-039	Spectro-Systems Corp.	78/05/15	G	79/05/04	RAL	HQ	Temperature Measurement	S-50,206
438	81-054	Sperry Corp.	81/06/12	WD	84/02/27	RAL	SAN	Oil Purge Gas Lift Value	S-55,201
439	81-055	Sperry Corp.	81/06/12	WD	84/02/27	RAL	SAN	Welded Pipe Connection	S-55,202
440	81-056	Sperry Corp.	81/06/12	WD	84/02/27	RAL	SAN	Exhaust Scrubbing System	S-55,203
441	81-057	Sperry Corp.	81/06/12	WD	84/02/27	RAL	SAN	Burning Chloro-Fluorcarbons	S-55,204
442	81-058	Sperry Corp.	81/06/12	WD	84/02/27	RAL	SAN	Geothermal Electric Generation	S-55,205
443	81-059	Sperry Corp.	81/06/12	WD	84/02/27	RAL	SAN	Welded Geothermal Condiuts	S-55,206
444	81-060	Sperry Corp.	81/06/12	WD	84/02/27	RAL	SAN	Gravity Head Control Method	S-55,207
445	81-061	Sperry Corp.	81/06/17	G	85/01/13	RAL	SAN	Geothermal Pump Downhole	S-55,208
612	83-024	Sperry Corp.	83/12/27	G	85/01/13	RAL	SAN	Restoration in Geothermal Energy	S-58,108
68	77-029	Sperry Rand Corp.	77/05/16	G	78/07/20	RJM	BAO	Geothermal Pump	S-47,483, Pat. 3,998,896
69	77-030	Sperry Rand Corp.	77/02/23	G	78/07/20	RJM	BAO	Calibration Circuit	S-47,481, S.N. 810,220
123	78-053	Sperry Rand Corp.	78/01/27	G	80/12/03	RAL	CH	Resonator	S-49,157, S.N. 114,039
124	78-054	Sperry Rand Corp.	78/01/27	G	80/12/03	RAL	CH	Transducer	S-49,159, S.N. 114,040
365	80-094	Sperry Rand Corp.	80/10/21	G	80/12/03	RAL	CH	Aconstic Teansducer	S-54,936, S.N. 114,038
326	80-054	SRI, Intl.	80/06/13	G	80/11/17	JWG	HQ	Red. of Silcon Halide	NAS7-100
327	80-055	SRI, Intl.	80/06/13	G	80/11/17	JWG	HQ	Melt Sep. of Silicon	S-53,799
328	80-056	SRI, Intl.	80/06/13	G	80/11/17	JWG	HQ	Liquid Sodium Spray	S-54,747
329	80-057	SRI, Intl.	80/06/13	G	80/11/17	JWG	HQ	Silicon Separation	S-54,226
330	80-058	SRI, Intl.	80/06/13	WD/C	81/01/22	JWG	HQ	Sodium Nozzle	S-54,749
352	80-081	SRI, Intl.	80/10/10	CL/C	81/02/23	RAL	AL	Heliostat	S-54,469
385	81-001	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Produce Silicon	S-49,275
386	81-002	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Seeding Silicon	S-51,332
387	81-003	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Purifying Silicon	S-51,333
388	81-004	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Cryolite	S-54,748
389	81-005	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Melt-Separator	S-54,233
390	81-006	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Synthetic Cryolite	S-54,234
391	81-007	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Leach Sodium Fluoride	S-54,236
392	81-008	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Purification	S-54,754
393	81-009	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Sodium Fluoride	S-54,750
394	81-010	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Bipulsating Silicon	S-54,751
395	81-011	SRI, Intl.	81/01/09	WD/C	81/03/17	JWG	HQ	Monopulsing Technique	S-54,752

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864	85-090	Stampfer, Martha R. et al	85/07/01	PW	86/06/12	RAL	LL	Enhanced Growth Medium-Culturing Mammary	S-63,826; DE-AC03-76SF00098
829	85-055	Stanford	85/02/19	G	86/02/20	RAL	LLL	Radio Frequency Storage Pulser	S.54,200
199	79-054	Stanford Jr. Univ.	79/08/06	D	80/03/21	MS	HQ	Batteries	
42	77-002	Stanford Jr. Univ. (Byer)	77/02/02	G	77/07/12	RJM	SAN	Frequency Extender	S-48,284, 48,285 & 48,286
456	81-072	Stanford Univ. (Boyarski)	81/08/03	WD	82/10/07	KDI	SAN	Computer Software	S-55,999
296	77-032	Stanford Univ. (Fred Hall)	77/03/29	CL	80/03/00	KLC	SAN	Electrolytic Cells	S-48,340
455	81-071	Stanford Univ. (Parker)	81/06/26	G	83/09/29	RAL	SAN	Learning Logic	S-56,326
335	80-063	Stanford University	80/07/15	WD/C	81/05/00	RAL	SAN	Electrodeposit of Sil.	EY-76-S-03-0326
336	80-064	Stanford University	80/07/15	WD	80/10/09		SAN	Tunnel Radio	DE-AC03-76SF00515
789	85-015	Stanford University	85/02/19	G	85/08/23	RAL	LLL	Binary Power Multiplier	S-61,448
47	77-008	Stanford University (Villa)	76/11/19	D	78/12/29	RAL	SAN	Elect. Transients Rec.	S-48,327
645	83-056	Stanford, University of	83/07/22	G	83/07/22	RAL	LLL	Ultra High Vacuum	S-59,432
857	85-083	Steinberg, Meyer	85/08/26	P			CH	Flash Pyrolysis of Coal & Biomass	DE-AC02-76CH---16
744	84-054	Stetter, Joseph R.	84/04/19	P			CH		S-59,136
745	84-055	Stetter, Joseph R.	84/04/19	P			CH		S-59,152
746	84-056	Stetter, Joseph R.	84/04/19	P			CH		S-60,857
452	81-068	Steyert, W. A.	81/07/28	G	83/07/20	RAL	AL	Miniature Solid State Gas Compressor	S-56,225
220	79-075	Steyert, W. A. (Empl/Inv)	79/08/21	WD	80/06/10	JWG	AL	Hydride Composite	S-51,852, S.N. 129,535
20	76-007	Steyert, W. A. (Empl/Inv)	76/03/25	G	76/12/30	RMP	SAN	Magnetic Refrigerator	S-45,679
33	76-020	Steyert, W. A. (U. of CA)	76/07/29	D	77/01/06	RMP	SAN	High-Temp. Switch	S-46,629
259	79-113	Stinecipher, Mary A.	79/11/30	G	81/04/20	MS	AL	Explosive	S-53,312
312	80-040	Stirling Colegate	80/05/23	G	80/09/05	WRM	AL	Liquid Injection	S-53,941
412	81-029	Stotlar, Suzanne	81/03/12	G	82/02/26	RAL	AL	Electric Detector	S-52,493
274	79-122	Sunpower, Inc./ANL	79/11/20	G	80/04/04	MS	CH	Stirling Engines	S-52,596
32	76-019	Sutphin, H. D. (U. of CA)	76/05/26	CL	77/11/18	WRM	SAN	Kryton Switch	S-45,677
415	81-032	Sutton, Mark L.	80/11/15	G	81/04/20	RAL	CH	Excavating Machines	S-53,560
219	79-074	Systems Science & Software	79/08/17	G	80/08/27	RJM	AL	Guarded Straddle Packer	S-52,111
878	85-104	TCI, Inc.	85/11/25	P			OR	Segmented Heater Cable	S-62,581
877	85-103	Techn. Corr. Instrum., Inc.	85/11/25	P			OR	Integrated Heat Generating & Sensing Sys	S-62,525 W-7405-ENG-26
256	79-110	Tedder, P. William	79/12/20	CL	80/04/24	KLC	OR	Ethanol	S-52,148
131	78-061	Teledyne Continental Motors	78/05/12	G	81/06/30	RAL	SAN	Combustion Engine	S-49,315
805	85-031	Tenn., Univ. of	85/07/12	G	85/12/11		CH	Oxygen Preparation	S-62,906: DE-AS05-80EV10363
239	79-094	Tennessee, Univ. of	79/07/20	G	80/10/09		OR	MHD Electrode	S-50,693
40	76-027	Texas Instruments, Inc.	76/11/15	G	79/02/02	RAL	CH	Solar Absorption Mat.	S-46,717
492	82-014	The Monosolar, Inc.	82/03/22	G	83/01/04	RAL	SAN	Photovoltaic Power Gen. Means & Methods	S-58,115
540	82-062	The Regents of the U. of CA.	82/07/02	G	83/05/5	RAL	AL	A Wrist Watch Dosimeter	S-54,654
780	85-006	Thermo Electron	85/03/12	P			CH	Ceramic Heat Exchanger	S-62,687

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
522	82-044	Thomas G. Matthews	82/05/25	G	83/07/21	RAL	OR	Formaldehyde Surface Emission Monitor	S-57,575
381	80-111	TRD Corp.	80/12/02	WD/CW	83/09/08	RAL	BAO	Self Propelled Furnace	S-54,336
382	80-112	TRD Corp.	80/12/02	WD/CW	83/09/08	RAL	BAO	Self Propelled Furnace	S-54,337
448	81-064	Tuan Vo-Dinh	81/05/18	G	81/12/28	RAL	OR	Dosimeter for PNAs	S-54,859
425	81-041	Turner, A. Mason (Cancelled)							
607	83-019	Union Carbide	83/04/18	G	83/07/20	RJM	CH	Vacuum Insulation	S-59,147
608	83-020	Union Carbide	83/04/18	G	83/07/20	RJM	CH	Vacuum Insulation	S-59,178
609	83-021	Union Carbide	83/04/18	G	83/07/20	RJM	CH	Vacuum Insulation	S-59,179
290	80-019	Union Carbide Corp.	82/12/20	G	83/04/20	RAL	OR	Alcohol	S-52,148
308	80-036	United Catalyst, Inc.	80/04/17	WD/C	81/11/02	RAL	OR	CO Methanation	S-54,042
193	79-048	United Nuclear Industries	79/07/05	G	80/07/16	JWG	CH	Radiation Monitor	S-47,072 & S-48,159
526	82-048	United States Steel, Inc.	82/06/07	G	83/12/29	RAL	OR	Recovery of Methane from Coal Seams	
317	80-045	United Stirling of Sweden	80/05/09	G	83/07/15	KDI	HQ	Stirling Engines	DEN-3-56 (W-2128)
318	80-046	United Stirling of Sweden	80/05/09	G	83/07/15	KDI	HQ	Stirling Engines	DEN-3-56 (W-2129)
319	80-047	United Stirling of Sweden	80/05/09	G	83/07/15	KDI	HQ	Stirling Engines	DEN-3-56 (W-2130)
98	78-028	United Technologies Corp.	76/12/03	D	81/11/16	KDI	BAO	Wire Turbine	S-47,413 (4,083,651)
120	78-050	United Technologies Corp.	78/11/14	G	79/07/05	RAL	HQ	Turbine Blade	S.N. 944,222
204	79-059	United Technologies Corp.	78/01/18	G	80/05/09		BAO	(same as W(I)-104-79)	S-49,644
222	79-077	United Technologies Corp.	79/01/30	D	82/01/12	RAL	SAN	Tube Holder/Gas Sep.	S-51,315
249	79-104	United Technologies Corp.	79/01/10	G	80/05/09	JWG	BAO	Vacuum Pump	S-49,644
473	81-089	United Technologies Corp.	81/12/28	G	84/12/06	KDI	HQ	Blade Pitch Actuation System	S-49,804
474	81-090	United Technologies Corp.	81/12/28	G	84/12/06	KDI	HQ	Wind Turbine Blade Pitch Control System	S-49,801
794	85-020	United Technologies Corp.	82/05/24	P			CH	Separation Germanium	S-56,635
604	83-016	Univ. of CA LANL (Archuleta)	83/03/15	G	83/09/29	RAL	AL	Polycarbonate Tube - Lab Animals	S-59,383
872	85-098	University of Chicago	85/11/14	PX	85/12/11	RAL	CH	Combined Sensor Device for Detecting Tox	S-59,136 W-31-109-ENG-38
873	85-099	University of Chicago	85/11/14	PX	85/12/11	RAL	CH	Sensor Array for Toxic Gas Detection	S-59,152 W-31-109-ENG-38
874	85-100	University of Chicago	85/11/14	PX	85/12/11	RAL	CH	Electrochemical Methane Sensor	S-60,857 W-31-109-ENG-38
875	85-101	University of Chicago	85/11/14	PX	85/12/11	RAL	CH	Selective Chemical Detection by Energy	S-62,398 W-31-109-ENG-38
876	85-102	University of Chicago	85/11/14	P			CH	Hoziontal Electro Magnetic Casting of	S-62,969 W-31-109-ENG-38
59	77-020	UOP, Inc.	77/08/02	D	78/09/15	WRM	HQ	Electrocatalysts	S-50,237
24	76-011	Utah, Univ. of	76/05/03	G	76/09/24	RMP	HQ	Metal Damage Detector	S-46,750
67	77-028	Utah, Univ. of	77/06/06	G	78/05/26	RAL	NV	Catalyst	S.N. 756,306
470	81-086	Vanderborgh, Verzino, et.al.	81/11/18	WD	83/09/18	RAL	AL	Liquid Carbon Dioxide of Nat. Hydro.	S-57,267
167	79-021	Varian Associates, Inc.	79/05/15	G	79/10/12	RAL	HQ	Crystal Growing	S.N. 119,913
262	79-116	Varian Associates, Inc.	79/11/28	G	83/03/21	RAL	OR	Microwave	S-52,164
345	80-073	Varian Associates, Inc.	80/07/28	G	84/05/11	RAL	OR	Gyrotron	S-54,809
523	82-045	Varian Associates, Inc.	82/06/01	G	83/07/21	RAL	AL	Solar Cell Obscuration	S-57,874

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524	82-046	Varian Associates, Inc.	82/06/01	G	82/07/21	RAL	AL	Improved Spectral Splitters	S-57,894
525	82-047	Varian Associates, Inc.	82/06/01	G	82/07/21	RAL	AL	Second. Concentrator Lens Cover Glass	S-57,895
527	82-049	Varian Associates, Inc.	82/05/21	G	85/02/28	RAL	SAN	Cascade Solar Cells	S-55,931
555	82-077	Varian Associates, Inc.	82/07/27	WD	84/08/15	RAL	SAN	High Power Broadband Drift Tube Load	(SAN 314)
432	81-048	Wayland, Henry Parker	81/06/01	WD	83/03/30	RAL	OR	Crystalline Fiber	S-55,625
520	82-042	Wayne C. Corvin	82/05/24	G	82/08/31	RAL	SAN	Instrument for Measuring Fault Current	S-58,119
3	75-003	Westinghouse	74/07/02	G	75/05/14	RMP	HQ	Microwave Sensor	S-42,835 (S.N. 369,664)
4	75-004	Westinghouse	74/07/02	G	75/05/14	RMP	HQ	Microwave Sensor	S-39,984 (S.N. 328,220)
41	77-001	Westinghouse	76/08/30	D	78/07/21	WRM	CH	Dietectric Spacer	S-47,530
44	77-005	Westinghouse	77/03/09	D	78/07/21	WRM	CH	Submerged Jet Cutter	S-47,529
46	77-007	Westinghouse	76/12/03	G	77/09/27	RJM	CH	Casting Material	S-47,546
55	77-016	Westinghouse	77/07/07	D	79/02/23	RJM	HQ	Nucl. Reactor Fuel Asm.	S.N. 304,292
84	78-014	Westinghouse	76/10/06	D	80/07/11	MS	CH	Insulating Gas	S-47,534, S.N. 808,571
125	78-055	Westinghouse	78/01/31	CL	80/10/10	WRM	CH	Dielectric Spacer	S-48,748
126	78-056	Westinghouse	78/04/03	WD	80/10/31	WRM	CH	Transmission System	S-49,125
213	79-068	Westinghouse	79/01/22	D	81/02/05	RAL	CH	Transmission Lines	S-49,893, S.N. 021,391
214	79-069	Westinghouse	79/04/18	D	80/07/30	MS	CH	Transmission System	S-50,384
232	79-087	Westinghouse	79/08/20	D	82/07/29	KDI	SAN	Drilling System	S-51,505
233	79-088	Westinghouse	79/08/20	G	83/01/31	KDI	SAN	Geothermal	S-51,506
268	80-002	Westinghouse	80/01/17	D	80/08/28	RAL	HQ	Fuel Assembly	Pat 4,061,536
502	82-024	Westinghouse	82/04/02	G	83/01/11	RAL	AL	Floating Nuclear Power Plant	S-57,826
531	82-053	Westinghouse	82/06/24	G	83/03/01	RAL	CH	Solid Oxide Fuel Cell	S-56,064
532	82-054	Westinghouse	82/06/24	WD	83/01/28	RAL	CH	Solid Oxide Fuel Cell	RES 82-84
533	82-055	Westinghouse	82/06/24	WD	83/01/28	RAL	CH	Solid Oxide Fuel Cell	RES 82-149
534	82-056	Westinghouse	82/06/24	G	83/03/01	RAL	CH	Solid Oxide Fuel Cell	S.N. 323,641
535	82-057	Westinghouse	82/06/24	G	83/03/01	RAL	CH	Solid Oxide Fuel Cell	S.N. 323,286
536	82-058	Westinghouse	82/06/24	G	83/03/01	RAL	CH	Solid Oxide Fuel Cell	RES 82-100
537	82-059	Westinghouse	82/06/24	G	83/03/01	RAL	CH	Controlled Porosity And Geometry	S-56,093
560	82-082	Westinghouse	82/08/25	G	83/07/15	RAL	CH	Gas Insulated Transmission Lines	S-53,540
661	83-072	Westinghouse	83/08/22	WD	86/03/05	RAL	CH	Insulated Transmission System	S-60,225
800	85-026	Westinghouse	84/11/06	G	86/02/24	RAL	CH	Electromagnetic Pump	S-61,350
801	85-027	Westinghouse		G	86/02/24	RAL	CH	Electromagnetic Pump/Controlable Force	S-61,351
804	85-030	Westinghouse	85/05/02	CL	85/12/20	RAL	CH	Burnup Meter for Nuclear Fuel	S-62,353
437	81-053	Westinghouse Elec. Corp.	81/04/07	G	81/12/18	RAL	CH	Alkalize Tran Electrode	S-51,019
357	80-086	Westinghouse Electric	80/10/13	G	82/07/24	RAL	OR	Heat Pump	S-54,839
446	81-062	Westinghouse Electric Corp.	81/02/13	G	83/03/01	RAL	CH	Fuel Cell Generator	S-55,241
507	82-029	Westinghouse Electric Corp.	82/02/08	G	84/08/28	RAL	OR	4 Pole/6 Pole, Pole Change Phase Motor	S-54,819

ID	W(I) NO	PETITIONER	RECEIVED	STATUS	DISPOSED	ATY	GRP	SUBJECT MATTER	CONTRACT NO
508	82-030	Westinghouse Electric Corp.	82/02/08	G	84/08/28	RAL	OR	6 Pole/8 Pole, Pole Phase Motor	S-54,825
630	83-041	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-54,821
631	83-042	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-56,595 See W(I)83-041
632	83-043	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-56,596 See W(I)83-041
633	83-044	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-56,599 See W(I)83-041
634	83-045	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-57,505 See W(I)83-041
635	83-046	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-57,534 See W(I)83-041
636	83-047	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-57,544 See W(I)83-041
637	83-048	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-58,089 See W(I)83-041
638	83-049	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-58,526 See W(I)83-041
639	83-050	Westinghouse Electric Corp.	83/05/23	G	84/05/25	RAL	OR	Heat Pump	S-58,524 See W(I)83-041
710	84-019	Whitten, W.B., et al	84/03/22	P		RAL	OR	Self-scanning CW dye laser	S-61,121; W-7405-ENG-26
243	79-098	Willey. Melvin G.	79/05/14	G	80/12/19		OR	Drafting Instrument	S-52,167
241	79-096	Willey, Melvin G.	79/05/14	G	80/12/19		OR	Drafting Instrument	S-52,165
242	79-097	Willey, Melvin G.	79/05/14	G	80/12/19		OR	Drafting Instrument	S-52,166
642	83-053	Windtech, Inc.	83/06/21	G	83/10/28	RJM	HQ	Back Stop-Patent Project R-2777	
75	78-005	Winnick, Jack, Dr.	78/06/06	G	78/03/11	NEA	CH	Electrochemical Sulfur	S-49,329
880	85-106	Wipf, Stefan L. (Univ. of CA)	85/12/09	P			AL	Magnetic Field Transfer Device	S-62,242; W-7405-ENG-26
913	86-030	Witherspoon, Linda	86/03/28	G	86/07/18	RAL	AL	Wafer Handling & Placement Tool	S-64,410; 26/1631
334	80-062	Wodtke, C. H./Smith, C. E.	80/05/20	C	83/03/10	RAL	OR	Welding	S-50,016
600	83-012	Wren, George	83/03/30	D	83/08/23	RAL	OR	Fibrous Zirconia Thermal Insulation	S-58,019
288	80-017	Wright, Harlan C.	80/01/22	WD	80/09/24		OR	Molecular Leak Valves	S-52,956
905	86-022	Zeigler, John M.	86/03/03	PX	86/05/27	RAL	AL	Novel Poly (Silane-Metalloxane) Photores	S-62,439; DE-AC04-76DP-00789
906	86-023	Zeigler, John M.	86/03/03	PX	86/05/27	RAL	AL	Novel Poly (Silyl-Silane) Homocopolymers	S-64,413; DE-AC04-76DP-00789
904	86-021	Ziegler, John M.	86/03/03	PX	86/05/27	RAL	AL	Improved Methods-Synthesis of Polysilane	S-63,429; DE-AC04-76DP-00789
641	83-052	Zimpro Pollution Control	83/06/20	WD	83/09/28	RAL	LLL	Enhancement Peat Dewaterability	S-60,063
151	79-005	Zucker, O. S. (U. of CA)	79/02/12	CL	79/08/29	RAL	SAN	Hydroelectric System	S-47,303

Senator DOMENICI. Let me ask just one question of Dr. Bloch.

Dr. Bloch, in terms of university/business/lab relationships, you discussed in your testimony university/business relationships that are being enhanced by some of your programs. Do you have any examples where you have been part of bringing the three together, the labs that are public, the universities, and the private sector?

Dr. BLOCH. Well, I don't know if I can give you examples, but I can point out particular areas in research, which is a very important area because we live—in the future, we will live off of new materials more than classical materials.

There is a close cooperation in many of the universities between the material research laboratories that the National Science Foundation has been—has established over the years and has been going on for 15 years. In fact, it started—really, we took the laboratories over from DARPA, and some of the national laboratory facilities. Just think of the synchrotron radiation sources, which are very important kind of instruments, big instruments, in materials research today. And these are available for essentially universities and they're available for their own use, and they are available also to the private sector. And we have a number of programs where individuals from the university and individuals from a particular business or company do work together, jointly do research work together, using some of these facilities. So there are many examples of this sort.

Senator DOMENICI. But your programmatic function is to leverage the two. If the third comes in, as you are describing it, more—all the better.

Dr. BLOCH. That's right.

Senator DOMENICI. Your program has private and university interaction.

Dr. BLOCH. Private business/university interactions primarily, right. But we also depend very heavily on some of the instrumentation that is available through the national laboratories.

Senator DOMENICI. One last followup question. The Congressman hit on a point that continues to concern all of us, and that's what appears to be just the accidental tying together of an idea or the development of something in a weapons lab with some other agency of the Government or some other institution. We know of some. The medical pump that was involved here, invented here, was almost an accident of the medical school finding some physics information and getting tied up with the labs and they gave them the physics to prove up the pump. But I find that it's difficult to get big agencies of the Government that have a function to take the research that's going on somewhere else and apply it to their area.

Is there any place in the Government where that case could be presented to someone so that the VA, the Veterans' Administration, which is spending billions in health care, won't all by itself pass judgment on whether they should fund a research program in conjunction with a national laboratory, that somebody else would come up over the top and say "You ought to do it."

Is there anything in the Government that does that now?

Dr. BLOCH. I don't know if there's anything in the Government or if there should be anything in the Government, really. I agree with you, that this accidental, as you—by the way, one shouldn't neglect to recognize that accidents are sometimes very beneficial and it's better than not doing anything at all. But I'm not so sure that an organized kind of approach is really the right answer. I think if there were more openness, openness of minds is what I have in mind, on all sides, then I think that would happen very automatically. And in order to foster that, I think the information has to be made available.

You talked before about secrecy, and I agree fully. Secrecy—you know, there has to be secrecy at times. But I think we probably overdo it, and especially when it comes to basic research. Basic research results, be they developed in a national laboratory or university, should be available to everybody. And that might be the best way, you know, of making sure that the information is being used and utilized and exploited.

Senator DOMENICI. Thank you very much.

Mr. LUJAN. Excuse me.

Dr. Decker, you sit on that FCCSET thing under OSTP, the Federal Coordinating—wouldn't that be kind of where you would go to cross-fertilize departments, if that's what——

Dr. DECKER. The particular FCCSET Committee that I chair deals solely with supercomputers and supercomputer issues, and there we do try to coordinate those activities across the Government.

Mr. LUJAN. But there are different subcommittees that could address a medical problem or something like that?

Dr. DECKER. Erich is a member of FCCSET and maybe can answer that better than I can.

Dr. BLOCH. Well, you want to be very careful. There are a number of committees on the FCCSET that address various specific areas.

Mr. LUJAN. What the Senator was asking, someplace you can go to to bring all the different——

Dr. BLOCH. Well, you want to be careful that you don't—you know, a committee is not necessarily the solution to the problem, because many of these problems are at a very detailed kind of a level, and the people that are sitting on FCCSET don't necessarily have that knowledge or that background or that information available. So you've got a problem there also.

You can only look at committees of that sort, which are fairly high level committees, as policy-setting kind of committees, coordinating on a very broad scale, but not at the detailed level that Senator Domenici addressed before.

Senator DOMENICI. Thank you very much. We appreciate both of you attending and coming all the way out here to be with us.

We're going to take a 5-minute break. We'll convene in 5 minutes—Well, maybe we'd better make it 10. There's a lot of people here.

[Whereupon, the committees were in recess.]

Senator DOMENICI. All right. The hearing will please come to order.

Our next witnesses are panel two. Let me indicate we have one additional panel. We're going to try to expedite the testimony. Panel two is Mr. Irwin Welber, president of Sandia Laboratories here in Albuquerque, and Dr. Sig Hecker, director of Los Alamos National Laboratory.

I understand both of you have prepared statements. With your indulgence, we would make the statements a part of the record and we would ask that you attempt to abbreviate them as best you can.

Dr. Hecker, would you proceed.

STATEMENTS OF DR. SIEGFRIED S. HECKER, DIRECTOR, LOS ALAMOS NATIONAL LABORATORY; AND IRWIN WELBER, PRESIDENT, SANDIA NATIONAL LABORATORIES, ALBUQUERQUE, NM

Dr. Hecker. Thank you very much, Senator Domenici. It's my pleasure to be here this morning, especially to be at a hearing in our home court in New Mexico instead of in Washington, DC. It's a lot fewer plane rides to get there.

I would like to, indeed, also address the translation of research to technological applications, since as was pointed out earlier, it is indeed important for a strong national economy as well as for a strong national defense. I think economic competitiveness is really taking on a new dimension in the current environment of an international marketplace. I think we must now as a nation maximize the return as measured in terms of advanced technology from our investment in Government-sponsored research and development.

The critical roles that are played by the national laboratories and those of the universities were discussed earlier in the first panel. What I would like to do is to discuss the role of the Los Alamos National Laboratory and also to discuss to some extent what the prospects are for the future.

Let me first just state a few things about the Los Alamos National Laboratory. As you know, it's a Government-owned, contractor-operated national laboratory, operated by the University of California for the Department of Energy. We have approximately 8,000 full-time equivalent employees, with an annual budget of about $800 million. Our primary mission is one of research and development for national defense, with the design and development of nuclear weapons being our most important responsibility.

However, half of the laboratory's activities are in areas other than nuclear weapons related, and that is in other areas of defense and energy related R&D. Hence, we view the laboratory as a national resource in science and technology that's responsive to problems of great national importance.

Now, the strong national security mission orientation of the laboratory makes technology transfer a necessity and not just a nicety. There would be no production capability, in my opinion, in the nuclear weapons complex were it not for the continual interaction of the laboratory with the integrated contractor-operated production plants.

At Los Alamos, technology transfer is—and I believe always has been—really a way of life. We're conducting R&D programs also now directly for the Department of Defense, such as those on advanced conventional munitions and also in the area of strategic defense. We are currently developing very close ties with the Department of Defense industrial complex, which I might add is considerably larger than the Department of Energy industrial complex. We are paving the way for effective technology transfer with the Department of Defense.

I cite these examples to make the point that the weapons laboratories in general, and Los Alamos in particular, clearly have the basic ingredients for successful technology transfer. We are involved in all stages of research—that is, applied and basic—and in all stages of development, exploratory and advanced. We have developed a close link from world class research to the final product, and I maintain that the process of technology transfer has worked extremely well within the defense community.

Let me turn next to technology transfer in the private enterprise, which is more of the topic here this morning. The transfer——

Senator DOMENICI. Excuse me, Dr. Hecker. Let me see if I understand.

You said you believe it's working rather well in the area that you described. Is that not its actual intent; that's what it's supposed to do?

Dr. HECKER. Absolutely. That is part of our mission, and that is why it works so well.

The transfer of technology, however, to private enterprise then and to the private marketplace needs, in addition, a very close interaction with private enterprise because it really does have the understanding of marketing and economics, as well as the ability to engineer and mass produce products. Of course, private enterprise needs economic incentives.

Now, the laboratories can contribute to this technology transfer to private enterprise in several ways. First of all, there's what I'll call technology pull. Second, collaborative research and contract research, and third, entrepreneurial spinoffs. Let me first touch on technology pull.

I think this is the area where the weapons laboratories have really had their greatest impact on technology in the private sector. And by technology pull, I mean the process of creating a consistent and demanding market for improved products and for interacting with industry to develop and to test such products.

The best example for Los Alamos is in the area of computer technology. That is that we've played a significant role in the development of state-of-the-art computer technology in the United States. In fact, I believe we've been the major force in driving the development of supercomputers and also in establishing the role of large-scale, scientific computations, as a rule, where it is now a legitimate partner to theory and to experimentation.

Our pervasive role in the advancement of computer technology was really stimulated in many ways. Our national security programs have continued to require computational capabilities that are beyond what has been commercially available, and the physical phenomena that are associated with nuclear weapons are so complex, and experimentation is so difficult, that large-scale calculations are a necessity.

We have been a most demanding customer and have also provided a reliable, long-term market for the next generation of computers. We have also been willing to take the first of new classes of computers and, in fact, worked with industry in their development as well as their refinement. We have played pivotal roles with IBM, Control Data Corp., and with Cray Research, Inc. We also are currently working with Intel Corp. and with Floating Point Systems in pioneering massively parallel computation, which is really the wave of the future for large-scale computation.

Now, in addition to our influence on the machines—the hardware end—we have also developed software compilers, operating systems, mass data and file storage systems, computer graphics, computer networks, and many of these have been incorporated in the private sector and at universities. In fact, the National Science Foundation's supercomputing centers have relied heavily on Los Alamos to get them into the supercomputing business.

There are many other examples of technology pull, such as in the area of laser technology or micromachining. I won't have time to detail these here.

Now, I cited this role, this very important role, because it's one that's generally not appreciated, especially if one simply looks at the patent statistics that were mentioned earlier this morning.

The second area that I mentioned is collaborative research and contract research. Again, that's another effective mechanism of transferring the technology to the private sector. We have always collaborated extensively with universities and in the past 5 years have done more so with industry. We have particularly found that visiting industrial staff members are a most effective means of collaboration, and that is these are researchers from private industry who have joined us at the laboratory for periods up to several years. They have been kept on company payrolls, but the laboratories provide space, technical support, and interaction.

Contract research, another alternative, here laboratory employees do research directly with private support. Again, the leverage for private industry is substantial. However, the overall Federal process makes this rather cumbersome. Currently at Los Alamos we have approximately 3 million dollars' worth of support from private industry.

Let me turn to the third way of technology transfer, and that is of entrepreneurial spinoffs. As a result of our research, the development of our science and technology base, and our programmatic work at the laboratory, the atmosphere for technical innovation is superb. In many of these, the technical innovations are ripe candidates for technology transfer to the private sector. However, the successful commercial development requires industry that's willing to take a risk, or it requires individual entrepreneurs who are willing to take a risk and often really willing to risk their professional careers. The Government must encourage the private sector by demonstrating that it—that is, the Government—can be a reliable partner in the exploitation of technology transfer.

Industry needs clear guidance from Congress and I think quick and consistent response from the executive agencies, because timeliness is certainly an all-important ingredient for economic success. The laboratory's success in entrepreneurial spinoffs is detailed in my written remarks and also in the Technology Transfer Report that we have submitted for the record.

I would just like to summarize it in the following fashion. We have had approximately 25 start-up companies that have been formed in the past 6 years based on technology that's developed at the laboratory, and just to name a few, these include such areas as flow cytometry, a technology to quickly identify and sort cellular and micro-cellular bodies. Second, a novel and compact low-voltage carbon dioxide laser that's been commercialized. Third, passive methods for electronic identification. Fourth, practical applications for magnetic refrigeration. And fifth, geothermal instrumentation and drilling technology. Those are just a few of the examples.

We have also developed some new innovative approaches to try to spur technology transfer, such as holding a technology fair at the laboratory, to showcase our materials technologies for private industry.

Let me touch last on the Government role. I believe that Congress and the President have certainly recognized the need to more fully exploit the Government-sponsored research to enhance our economic competitiveness, and certainly so far this morning that's been clearly stated, and also the different acts that have been enacted to encourage that transfer have been discussed. However, there are in these acts certain exclusions that do not provide the incentives to the weapons laboratories, and indeed, we now apply for all waivers on a case-by-case petition basis only.

Furthermore, we view that current legislation that's being considered, particularly section 3031 of House Bill 4428—I think it was earlier referred to as the Solomon amendment—as being even more restrictive than the public laws on record. So, therefore, we believe that as a laboratory we are really receiving mixed signals from the Government. On the one hand, there's a general push to have the national laboratories work harder on transferring technology. On the other hand, the all important process of patent waivers is still one that's very time consuming and cumbersome, and particularly so at the weapons laboratories.

I also believe that the University of California for the Los Alamos Laboratory could enhance this process of timely technology transfer by delegating from the University to the Laboratory the authority to elect or waive title—of course, on its behalf. In spite of these difficulties, however, we have been quite successful in technology transfer to promote economic development through the spinoffs, but I believe that we have only really scratched the surface. If we are to do more and to take advantage of the resources that are available at the weapons laboratories, we need to encourage private enterprise through friendly legislation and through helpful policies of implementation. Such action would have a positive impact on the national economic development and I believe is absolutely crucial for regional economic development in New Mexico, because certainly, as I don't really need to point out, both of the national laboratories in New Mexico are weapons laboratories.

The question has been raised as to whether the laboratories can encourage technology transfer without undermining their main mission and negatively impacting national security. I would maintain that an aggressive interaction with private industry not only does not undermine our national security programs, but is, in fact, imperative to our doing these programs well. I submit to you the example that I cited of the influence that the laboratory has had on computer technology in this country is a very convincing example.

I thank you for the opportunity to speak on a subject so important to this Nation.

[The prepared statement of Dr. Hecker with attached report follows:]

JOINT CONGRESSIONAL HEARING SPONSORED BY THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY AND SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

FOCUS '86: COMMERCIALIZING FEDERAL LAB TECHNOLOGIES

Siegfried S. Hecker, Director
Los Alamos National Laboratory
September 4, 1986

I. Introduction

The national security of the United States of America depends upon a strong defense and a strong economy. Technology is a key ingredient to both. Today we see our technology more severely challenged than any time since World War II. The U.S. continues to lead the world in basic research and the generation of innovative ideas that are the seeds of tomorrow's technology. However, the process of translating these ideas to products in the marketplace needs to be improved if we are to improve our national defense and economic competitiveness.

With the advent of a truly international economy, it has become important to focus on international competitiveness. This requires that we understand the international market and that we learn how to more fully utilize government research and development expenditures. The Department of Energy (DOE) National Laboratories represent a significant federal R&D expenditure and a most powerful national resource for the exploitation of technology. In the energy and technology areas, the laboratories are engaged in long-range, high-risk, high-potential-payoff R&D where either the initial prospects of profits are remote, society at large (in contrast to individuals) could benefit, or where industry lacks incentives.

The Laboratories have excellent scientific and engineering staffs capable of responding to complex, multi-disciplinary problems. They have extensive research facilities and organizational structures and traditions that allow for the ready assembly of research teams to tackle complex problems. To ensure state-of-the-art technology, many of the laboratories also support world-class basic research, which complements research done at universities. The combination of research and applied technology at the national laboratories provides an ideal source for advanced technology and a natural bridge from the education and research emphasis at universities to the product and profit orientation of industry.

II. The Los Alamos National Laboratory

I view the Laboratory as a national resource in science and technology. We must strive for unquestionable excellence and be prepared to solve problems of great national importance. Our goal is to do state-of-the-art technology that is responsive to the programs important to the DOE and the nation. Our programs are predominantly oriented towards national security. They range from the design and development of nuclear weapons which is our statutory responsibility, to strategic defense research, and to the development of new energy technologies.

In such a strongly mission-oriented laboratory, basic research provides an indispensable base for technology, helps to define the Laboratory's future technology, and provides the very important coupling to university research and the academic community. I am convinced that to continue to do advanced technology over a long period of time and over a broad and often unpredictable range of technologies, we must invest heavily in basic and applied research at our Laboratory. Only through such an investment will we retain the talent that can change directions easily and stay at the forefront of technology. This investment is particularly important at the weapons laboratories (Los Alamos, Livermore and Sandia National Laboratories) to attract and retain the best talent to work on national security programs.

Our basic mission, the design and development of nuclear weapons, has prepared us well for technology transfer. We design and test the nuclear weapons, and the DOE integrated contractors build them for the stockpile. The crucial elements required for technology transfer have been here since the beginning: a) a strong research base promoted by some of the best scientists in the world, b) the ability to take research ideas through the stages of exploratory, advanced and prototype development, and c) a strong and direct coupling to industry and their product. Basic research in many areas of particular importance to national security has been pioneered here. For many other areas we have had smaller, but yet important "window on the world" research efforts. Exploratory and advanced development has been encouraged not only by the final product, but also by the need for large-scale experiments, such as those at the Nevada Test Site. This has promoted an atmosphere of technological creativity and innovation that is unsurpassed. The coupling to industry is intimate through the DOE network of integrated contractors. The weapons laboratories not only see their weapon design through the product development and production phase by interacting with the contractors, but also retain technical responsibility through stockpile and retirement.

Hence, the ingredients for technology transfer are there. We have demonstrated this process successfully for over 40 years within the DOE defense community. We are now working on several programs directly for the Department of Defense (DoD). These include an advanced armor/anti-armor initiative with the Defense Advanced Research Projects Agency (DARPA) and a neutral particle beam project with the Strategic Defense Initiative Office. We are in the process of developing appropriate working relations with the DoD military-industrial complex to effectively transfer technology.

Technology transfer to the private-sector marketplace, however, is a different matter. It is much more difficult and less focussed. What has the technology transfer role of the Laboratory been and, in fact, what should that role be for DOE national laboratories that are primarily involved in national security work? I will try to answer these questions.

III. Technology Transfer to Private Industry

To make technology transfer successful at the weapons laboratories we need to capitalize on their strengths without undermining their basic mission. Their strengths are their broad research and development capabilities and an atmosphere of technological innovation. For technology transfer to work, it must be mutually beneficial. The private sector adds an understanding of marketing and economics along with the ability to engineer and mass produce products. It has often developed ideas much beyond initial expectations and, in turn, spawned new ideas and innovations.

The term technology transfer is a misnomer. It implies a one-way street. In fact, the successful translation of research into technological applications requires an effective exchange of ideas between organizations that are research and development oriented and those that are product oriented. We can identify at least several types of exchanges that can lead to successful technological applications: a) technology pull, b) collaborative research and contract research, and c) entrepreneurial spinoffs.

Technology Pull. In my opinion the weapons laboratories have had the greatest impact on technology through technology pull. For example, their impact on computer technology and large-scale computational science has been enormous.

The weapons laboratories, and Los Alamos in particular, have played a significant role in the development of our present state-of-the-art in computer technology, especially in supercomputers. For more than four decades, we have provided a consistent and demanding market for improved products, we have shared our technologies with industrial firms, and we have worked with the industry to set standards and improve performance.

The Laboratory was responsible for the development of one of the first large-scale computers, the MANIAC. As soon as industrial firms began to build computers commercially, the Laboratory actively encouraged them by working with them and testing and purchasing their products. The Laboratory was an early customer of IBM and worked very closely with IBM throughout the 1950s to advance both hardware and software for scientific computing. We developed library software and compilers for the 701-704-709 series of computers. The IBM 7030, which was the most advanced machine available when it was built, was designed jointly by Los Alamos and IBM. The 7030, while not a commercial success in itself, provided much of the technology base for the entire IBM 360 series.

Our lease of the first Cray-1 supercomputer was critical to the survival of Cray Research Incorporated during its formative years. In our evaluation of the serial number 1 machine, we showed that it would benefit greatly if additional circuitry were added which would allow the machine to recover from simple memory errors. This led CRI president Seymour Cray to immediately add an error check function to the memory of their subsequent machines. We just celebrated, in a ceremony on August 28, the tenth anniversary of the installation of Cray serial number 1 and ten years of close collaboration with CRI.

The technology for producing computer-generated color film was developed at Los Alamos in the late 1960s and transferred to industry. Our technology was the basis for developments in color generated movies for the next ten years, and the industry is still using it today.

The Common File System (CFS), a mass data and file storage system which supports computer networks, was developed at Los Alamos and has been transferred to DOE and DoD sites and to industry. Several National Science Foundation supercomputer networks use the CFS.

We have been active on the frontier of parallel computation. We worked with Deneloor, a small start-up company, and with their product, the Heterogeneous Element Processor. More recently we have been working with the Intel hypercube, and discussions are currently underway with Floating Point Systems which will probably lead to the installation of a FPS T-series machine at Los Alamos.

Tektronix has been very responsive to our feedback, which has been a considerable resource to them in improving their products. For example, we modified the 4014 graphics terminal to increase its speed by a factor of 30 and subsequently they incorporated a high-speed option into their product line.

Our current work on ultra-high speed graphics is helping Gould understand and develop related products. We initiated a joint project between Cray and Gould based on a major advance in which we took equipment from the two manufacturers and integrated them together.

We helped DEC perfect their ALL-IN-ONE software package for electronic office automation. We have had a long relationship with DEC as well as other manufacturers (such as CDC, Gould, SUN Microsystems, Cray, IBM...) in which they consider us a "strategic account."

We have had a long-standing relationship with CDC and most recently have collaborated with them on their CAD/CAM Integrated Computer-Aided Engineering and Manufacturing package.

Our software requirements have greatly influenced CRI's compiler development. We are a primary test site for their Fortran compiler, and Cray will not release the product until we clear it. We are currently assisting them to evaluate and strengthen their new UNICOS operating system.

We are active in establishing national standards, especially in computer graphics, Fortran, and networks. Because we are several years ahead of others in defining needs because our applications are so very demanding, manufacturers find that if they can satisfy our needs, their products will usually be acceptable to their commercial clients. Some computer vendors publicly state that their machines will have difficulty being a commercial success unless they can sell them to one of the major DOE Laboratories.

Los Alamos was one of the first sites to start building a computing network. Network Systems Corporation visited Los Alamos early in their product development cycle seeking our comments on their NSC hyperchannel.

We were one of the first sites to successfully operate a multivendor computing network. This places us in a position to influence vendors to make their equipment compatible with that of other vendors.

A large percentage of the Cray supercomputers are front-ended by IBM machines. IBM acknowledges our role in establishing this connection.

Much of the supercomputer technology has been pioneered at Los Alamos, and many organizations are modeling their computing facilities after those at Los Alamos. Our role in transferring the technology has ranged from assisting with the installation of the computing network at the Air Force Weapons Laboratory to assisting the NSF supercomputer centers in establishing their computing networks and in utilizing our software on vectorization and parallel architecture technology. When Dr. Larry Smarr, Director of the University of Illinois NSF supercomputer center, saw our "ultra-speed graphics project" he began plans to clone the system at the University of Illinois as quickly as possible.

In fact, Los Alamos has pioneered the use of large-scale computations as a legitimate partner to theory and experimentation. Our pervasive role in the advancement of computer technology was stimulated in many ways. First, our national security programs have continued to require computational capabilities beyond what has been commercially available. The physical phenomena are so complex and experimentation so difficult, that large-scale calculations are a necessity. This has made us a most demanding and long-term customer for the computer industry. We continually provide a reliable, long-term market for the next generation of machines. This, combined with our willingness to take the first of new classes of computers in order to satisfy our performance requirements, has made us a partner with the industry. And, as pointed out above, we have been an interactive customer. Many of the advances in hardware and operating systems were, and continue to be, made here and incorporated into the private sector. Clearly, the computer industry in which the U.S. still boasts supremacy in the international market has benefitted greatly from Los Alamos and the other weapons laboratories.

There are other examples of technology pull where the laboratories have played similar pivotal roles. Laser technology and micro-machining technology are two such examples, but their stories are too lengthy to detail here.

Collaborative Research and Contract Research. One very effective mechanism of technology transfer is to have the private sector collaborate in research with the laboratories. We have encouraged such collaborations with universities from the beginning. For the past five years we have also received interest from industry. Collaboration at the research stage is ideal because it typically does not involve proprietary information and can provide significant leverage for industrial firms. One of the best forms of such collaboration is through our industrial staff member (ISM) program. Researchers from private industry have joined us at the Laboratory for periods up to several years. They are kept on company payrolls but the Laboratory provides space and technical support.

Two recent examples illustrate this program: Dr. Joe Katz from SCIPCO came to work in our ceramics composite program, learning about our methods for growing single-crystal silicon carbide whiskers. Dr. Harold Dilworth came from Armco Steel Company to work on a new method of spectroscopic analysis of molten steel. The method, called Laser Induced Breakdown Spectroscopy, was developed to provide rapid elemental assay of molten steel. This project was jointly funded by the DOE and the American Iron and Steel Institute, of which Armco is a member.

In contract research, Laboratory employees do research directly with private support. Again, the leverage for private industry can be significant. However, federal restrictions make this a process that is cumbersome and quite bureaucratic. At Los Alamos we have $2.9M of private industry support for research in FY1986.

Entrepreneurial Spinoffs. As pointed out above, the Laboratory abounds in technical innovations as a result of its research, science and technology base development, and programmatic work. However, entrepreneurs are often required if these innovations are to reach the marketplace. Recent government actions have encouraged such entrepreneurship. The Laboratory has been actively assisting entrepreneurship to fulfill its obligations in technology transfer. The most recent report of the technology transfer activities at the Laboratory will be submitted for the record. Several specific examples are cited below.

a.) Flow Cytometry. In the mid-1960s, Los Alamos scientists developed the cell sorter that is the integral element of flow cytometry technology. This technology allows researchers to identify quickly and to sort cellular and microcellular bodies, and has become standard in disease detection efforts. The manufacture of flow cytometers is a $40 million per year industry concentrated mainly in three large firms. There are also two major suppliers of flow cytometers and hundreds of companies that manufacture the reagents used in flow cytometry. In addition, computer programs developed at Los Alamos for flow cytometry have been marketed by several firms.

b.) Pulse Systems, Inc. Pulse Systems was formed in 1979 by Ed McLellan, a Laboratory staff member working on our Antares laser fusion program. While working at the Laboratory, he invented a novel, compact, low-voltage CO_2 laser that had several advantages over existing high-voltage lasers. He petitioned the DOE for waiver of rights to the patent. He left the Laboratory in 1982 and received the waiver in 1983. Later that year, the company received a $1M venture capital investment.

The company has two laser products in the scientific market and a recent industrial product. Pulse Systems received a small award from NASA in 1985 followed by a $500,000 award in 1986. The NASA work is to develop a compact, light-weight, CO_2 laser for space applications.

c.) Amtech Corporation. In the early 1970s, the U.S. Department of Agriculture sponsored Laboratory research to develop a passive method of electronic identification of livestock. A technology was developed at Los Alamos that could provide not only identification information, but also the animal's body temperature when "interrogated" by a nearby reader. In 1978 the technology won an Industrial Research Magazine IR-100 award.

Several years of attempts to market this invention with a non-exclusive licensing right from DOE proved fruitless. Several of the program participants developed a business plan with the help of the Technological Innovation Program at the University of New Mexico. They identified other applications such as vehicle and railcar identification and warehouse inventory systems. A second request to DOE resulted in exclusive rights to two patents assigned to Amtech. The patent rights were crucial for the successful startup of this new company.

Two Laboratory employees currently are on leave-of-absence and are working with Amtech.

Seed capital was obtained by Amtech in 1984 from a computer services company that recognized the relevance of electronic identification to automatic data processing. Current business plans estimate that Amtech will be a multi-million dollar business employing over 100 individuals by 1991. The potential impact of this Laboratory technology on the regional economy is significant. (The owner of Amtech will be testifying at this Joint Hearing).

d.) Astronautics Corporation of America. Research at Los Alamos demonstrated the practical application of magnetic refrigeration for cryogenic applications. The technology employs the special property of certain magnetic materials that spontaneously cool when an applied magnetic field is removed. Los Alamos scientists discovered an efficient refrigeration method with potential applications for optical imaging systems, space systems, health service technologies, and supercomputers. Since 1975, support to develop this technology has come from a number of sources including DOE.

The principal investigator at the Laboratory worked on his own time with the Technology Innovation Center at the University of New Mexico to develop a business plan to commercialize the new technology. In 1985, the technology was transferred to Astronautics Corporation of America in Milwaukee, Wisconsin. Four Laboratory employees left the Laboratory and went to Astronautics, taking with them patent waivers from the Department of Energy for the technology; two of them are still Lab employees on a renewable leave-of-absence from the Laboratory. The company expects it will be about two years before commercial versions of the new technology will be available, but the increased efficiency of the new refrigerators should be at least twice that of comparable, existing refrigeration systems.

e.) New Approaches. The Laboratory also initiated several new approaches to encourage entrepreneurial spinoffs and technology transfer:

Los Alamos Materials Technology Inventory. In 1984-85, the Laboratory conducted a technology inventory of materials technologies we called Quest for Technology. The goal of QUEST was to find technologies, facilities, and expertise within the Laboratory that could be used by private industry. In this way the results of federally funded R&D could be made available to private companies to strengthen the national industrial economy, and the Laboratory could strengthen its technical base and broaden its research perspectives through closer relationships with the private sector.

QUEST was conducted in the Laboratory's Materials Science and Technology Division because materials technologies were likely to have commercial applications. QUEST identified 190 technologies, 90 percent of which were considered to be of commercial value. A subsequent market analysis of these technologies determined which QUEST topics had the highest potential for commercial development.

A seminar designed to disseminate this information to U.S. industry was announced in the Commerce Business Daily on May 2, 1985, and held at the Laboratory on August 27 and 28, 1985. The response to the announcement was excellent--67 people attended, representing 49 U.S. companies.

The long-range benefits of the Materials Technology Seminar to the Laboratory and the U.S. private sector will not be known for some time. However, more than 40 serious inquiries for further contact or information resulted from the two days of meetings. Some of these contacts have already lead to substantive discussions of collaborative research projects, intellectual property rights, and reimbursable work for industry. For many people at the seminar, it was their first visit to Los Alamos and their first contact with the Laboratory. For them the seminar provided an excellent opportunity to learn not only about some of the technologies at the Laboratory, but also about the many ways in which the Laboratory is able to work with the private sector.

Industrial Research Institute Spotlight Conference. In March 1986, the Industrial Research Institute (IRI) sponsored a conference with Los Alamos and Sandia National Laboratories to spotlight materials science and biotechnology research. The purpose was to feature work in those areas of technology that have industrial applications.

The objectives of the IRI are to enhance the effectiveness of industrial research. It promotes improved quality and application of research in industry through the cooperative efforts of its membership, which includes most of the major industrial firms in the country. An IRI task force has been working with the national laboratories to explore ways to form stronger ties between U.S. industry and the laboratories; the Spotlight Conferences are a direct result of those discussions.

About 75 representatives from 60 of the nation's best known firms attended the Conference. Laboratory presentations and tours were given by the Materials Science and Technology Division and the Life Sciences Division. Topics included composite materials, ceramics and single crystal whiskers, electrically active (conducting) polymers, coating technology, biocompatible polymers, gel analysis of proteins, Fourier transform flow cytometry, and nuclear magnetic resonance metabolic imaging.

IV. Regional Impact

Plans for regional economic development are often pinned to high technology because it offers the prospects for well paying new jobs without adversely affecting the environment. Nowhere is this more evident than in New Mexico. The sudden decline in demand for many energy-related natural resources has left New Mexico with high unemployment and in financial difficulty. The two national laboratories, Sandia and Los Alamos, along with the military bases and universities provide a major attraction for high-technology economic development.

The Laboratory contributes in many ways to regional economic development. There is, of course, the impact of direct employment and its multipliers. The Laboratory and its supporting organizations inject in excess of $2 billion/year into the economy of northern New Mexico. One-fourth of all personal income in the tri-county (Los Alamos, Santa Fe and Rio Arriba) area comes from the Laboratory. Thirty-eight percent of all jobs in the area are directly or indirectly supported by the Laboratory.

Recent technology transfer initiatives at the Laboratory that have regional impact include:

o	Established position of Tech Transfer Officer	1980
o	Initiated patent awards program	1981
o	Community enhancement seminar	1982
o	Los Alamos innovators forum	1982
o	Initiated University of New Mexico/Los Alamos course on entrepreneurship	1982
o	Established office of Industrial and International Initiatives	1983
o	Formal Lab policy on industry interactions	1983
o	Conducted technology inventory	1983
o	Began industrial initiatives roundtable	1986

The Laboratory works with a number of organizations within the State to promote the creation of a climate supportive of technological innovation. The Rio Grande Technology Foundation works with the Laboratory to match industrial needs with Laboratory technologies. Los Alamos forms the northern-most anchor to the Rio Grande Research Corridor. The Laboratory participates in many of the State's initiatives within the corridor to translate the technological wealth of New Mexico into new businesses, jobs, and economic growth. New Mexico Technet provides a rapid electronic communication link between Los Alamos and the rest of the Rio Grande Research Corridor. The Laboratory has supported the Technet project. We also have worked closely with the New Mexico Economic Development and Tourism Department.

In 1984, the Laboratory cosponsored a conference on small business incubators, resulting in the creation of the State's first incubator in Los Alamos in 1985. Operated by the Los Alamos Economic Development Corporation, the incubator houses several small start-up companies based on Laboratory-developed technologies.

Several Los Alamos employees serve on boards and commissions, such as

- Riotech Board of Directors
- New Mexico Technet
- New Mexico Science and Technology Commission
- New Mexico Research and Development Institute Technical Advisory Committee
- Los Alamos Economic Development Corporation Board
- Tri-Area Association for Economic Development
- Governor's Committee on Technical Excellence

V. Important Issues

The Los Alamos National Laboratory has had a major impact on technologies for national security. We have also had substantial impact on the private sector on technologies where we have provided technology pull, such as in the computer industry. It was the recognition of the resources available at the national laboratories and the erosion of the U.S.'s international competitive position that prompted the government to encourage more extensive technology transfer.

Technology transfer through entrepreneurial spinoffs, as illustrated above, was facilitated by such government actions. However, we are far from realizing the potential of our Laboratory in enhancing technology transfer on a national scale. We need to do more to encourage private industry to work with the laboratories. But in addition to innovative ideas at the laboratories, private industry must be convinced that the government (through its actions at the laboratories) will act expeditiously to let them develop these ideas on a timely and competitive basis.

Legislation in the early 1980's was aimed at making patent rights from government-sponsored research more accessible to private enterprise. The Stevenson-Wydler Technology Innovation Act (P.L. 96-480) of 1980 requires that the laboratories establish Offices of Research and Technology Applications (ORTA) to promote the transfer of federally-funded technology to the private sector. The Bayh-Dole Act (P.L. 96-517) of 1980 provided the rights of inventions developed under government contract to non-profit organizations and small businesses. P.L. 98-620 extended those rights to non-profit contractors of government-owned laboratories.

However, there are several aspects of current laws that hinder timely response of the weapons laboratories compared to other laboratories. Exceptions to P.L. 98-620 for government-owned, contractor-operated facilities that engage in weapons related programs make this process much more cumbersome and time consuming. The exceptions remove the right to elect title to inventions from non-profit contractors such as the University of California and allow waivers on a case-by-case petition basis only. To date, the DOE has informally taken a very restrictive interpretation of "weapons related" to mean all government-sponsored work at the Laboratory regardless of its direct weapons relevance.

In addition, we are concerned that new legislation being currently considered would be even more restrictive. Section 3031 of H.R. 4428 would require the Secretary of Energy to decide whether or not to assign to the contractor of laboratories involved in the nuclear weapons program any property rights to an invention for which the DOE has reserved the right to retain ownership. The language also states that the Secretary may consider the recommendation and written determination of the Military Liaison Committee in his decision. Such new restrictions will remove much of the incentive that industry needs for timely technology transfer from the weapons laboratories.

The technology transfer process at Los Alamos could also be enhanced by the University of California. The language in P.L. 98-620 mandates that the prime contracts for the laboratories must include a requirement that to "the extent it provides the most effective technology transfer, the licensing of subject inventions shall be administered by contractor employees on location at the facility." For Los Alamos to comply with the letter and intent of P.L. 98-620 and facilitate the timely execution of technology transfer, we believe it necessary for the University of California to delegate to the Director of the Laboratory the requisite authority to elect or waive title as the case may be on behalf of the University to government-funded inventions made at Los Alamos. We are presently negotiating for that delegation of authority.

VI. Summary

The national laboratories provide a resource for technology that must be utilized more effectively if the U.S. is to remain competitive in the international marketplace. The weapons laboratories in particular, with their strong mission orientation and the full range of basic research to applied technology, provide an atmosphere for technological innovation that is necessary for technology transfer. The government has recognized the need for more effective translation of government-sponsored research to applications. It has encouraged, and in fact mandated, the national laboratories to assist in this process.

For the weapons laboratories, however, the signals from government have been mixed. We have been quite successful at technology transfer in an atmosphere that is difficult and cumbersome. Current indications are that this atmosphere will become even more restrictive. The general concerns are ones of potential negative impact on national security programs. It is my opinion that a vigorous interaction with industry and an aggressive technology transfer effort will benefit the Laboratory and national security programs. The example given above of the interactions between the Laboratory and the computer industry illustrates this point.

It should also be reiterated that restrictions rather than encouragement of technology transfer at the weapons laboratories will be particularly severe on regional economic development in New Mexico, because both national laboratories in the State are weapons laboratories.

109

LOS ALAMOS NATIONAL LABORATORY

TECHNOLOGY TRANSFER REPORT

FY85

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Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

CONTENTS

I. INTRODUCTION.. 1

II. ACCOMPLISHMENTS

A. General.. 2-4

B. The Los Alamos Materials Technology Seminar............. 4-5

C. Hot Dry Rock Geothermal Energy Development Program Technology Transfer....................................... 5-6

D. The Los Alamos Small Business Center.................... 6-9

E. Collaborations with Industry............................ 9-11

III. STATE GOVERNMENT/LABORATORY INTERACTIONS

A. Membership on Boards and Commissions.................... 11

B. Loaned Executives to State Government................... 11

C. Technical Assistance and Evaluation..................... 12

IV. LOS ALAMOS COMMUNITY RELATIONS PROGRAM

A. Educational Outreach.................................... 12-14

B. Community Outreach...................................... 14-15

V. UNIVERSITY/LABORATORY PROGRAMS.............................. 15-17

VI. ISSUES

A. Industry Liaisons....................................... 17-18

B. Patents and Licensing................................... 18

C. Federal Laboratory Consortium (FLC)..................... 18

D. Information Development................................. 18-19

E. Internal Laboratory Motivation.......................... 19

F. Individual Entrepreneurship............................. 19

VII. APPLICATIONS ASSESSMENT.................................... 19

Appendix A. Companies Participating in the Los Alamos Materials Technology Seminar

Appendix B. Technology Transfer Program Plan

Appendix C. LA-10601-HDR

I. INTRODUCTION

The long-term vitality of the U.S. is not only dependent upon a strong defense but also on maintaining a strong economy. Staying ahead in technology is the key to both military and economic security. Thus, in agreement with DOE guidance, the Los Alamos National Laboratory encourages the transfer of federally developed technology for this purpose.

The Laboratory's Technology Transfer Program provides technology and technical assistance to US private industry, universities and educational systems, and State and local governments. These interactions have grown steadily over the past few years, primarily because of changes in federal policy and legislation that encourage appropriate collaboration between federal laboratories and the private and non-federal public sectors. This trend is expected to continue as US industry turns increasingly to technological innovation to improve their productivity and competitiveness in a global economy.

This report summarizes Los Alamos' interactions in FY85 with US industry, universities, and State and local governments. The benefits of these collaborative efforts are mutual. While the Laboratory is able to provide access to valuable technology, expertise, and unique facilities, it also strengthens the Lab's technical base, expands its programmatic perspective, enlarges the community of participants in ongoing programs, and forms valuable partnerships for mutual professional development among our staffs.

For more information on the Technology Transfer Program and the various ways in which the Laboratory can work with potential users of federally developed technology, please contact:

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II. ACCOMPLISHMENTS

A. General

1. KMS Fusion Optical Pin. KMS Fusion obtained a patent license from a Los Alamos scientist for a micro-balloon optical pin for use as a probe in high pressure pulses. Initially, the scientist was granted a patent waiver and received ownership of the technology. KMS Fusion is currently manufacturing and marketing the optical pin.

2. Radtech Corneal Probe. A circulating-saline radio frequency probe for corneal modification, developed by Laboratory scientists, was licensed by Radtech, Inc. of Albuquerque, which has developed a commercial prototype. This technology involves a probe that heats corneal collagen. The resultant shrinkage modifies the cornea shape and improves the optics. When applied correctly, this instrumentation can result in improved vision. While Radtech is now taking the responsibility for all further developments of the instrumentation for clinical experiments, Laboratory scientists continue to provide assistance on an occasional basis to ensure that the appropriate information is transferred to Radtech.

3. International Diagnostic Instruments Software for Corneascopes. Laboratory scientists developed an algorithm and associated computer software to enable detailed quantitative interpretation of the output of existing commercial corneascopes that are used to measure corneal shape. This software has been supplied to collaborators at the Dean McGee Eye institute in Oklahoma City who have in turn supplied it to several other vision research centers. One private firm that has benefited from this improved technique for interpreting results from their product is International Diagnostic Instruments of Tulsa, OK.

4. Surgical Tool. A bipolar electrosurgical device has been developed by Laboratory scientists, which enables a surgeon to perform conventional mechanical cutting and electrocoagulation of bleeding vessels with a single, compact instrument. The dual functions of the device make it particularly useful in microsurgery where the exchange of separate cutting and coagulating instruments makes it difficult for the surgeon to maintain concentration of the field under the operating microscope. The instrument has been tested with excellent results in the Department of Surgery at the University of New Mexico School of Medicine. Radtech, Inc. of Albuquerque is producing prototype devices and is negotiating for an exclusive license on the patent.

5. Dosimeter. Work on a personal dosimeter for measurement of rf and microwave electromagnetic field exposure has terminated at Los Alamos since the DOE has granted the Laboratory inventor the right to file for a personal patent on this technology. Privately funded research and development has been initiated and a prototype commercial product will be available soon.

6. Thermionic Integrated Circuits. Thermionic Integrated Circuits (TIC's) are a new type of electronics for use in hostile environments. They are a highly integrated form of vacuum tubes combining features of both vacuum tube technology and integrated circuit technology. TIC's will be used in environments where semiconductors cannot function or in a backup mode to provide critical functions in the event of a semiconductor failure.

During FY85, the Laboratory had two consulting contracts with firms interested in TIC's. One was with General Motors, which is interested in instrumenting jet engines with TIC's, and the other is with Northrop, which is assessing the market for the manufacture of TIC's.

7. Gene Library A unique library of human genetic material was established at Los Alamos during FY85. Compiled by scientists from Los Alamos and Lawrence Livermore National Laboratory, the library is a project to stock a complete collection of the human genetic code.

In order to separate the desired chromosomes, a sample is first isolated from cultured human cells. Next, individual chromosomes are sorted with the use of a flow cytometer. Researchers then employ the special chemical properties of enzymes to chop apart single human chromosomes into thousands of fragments. The tiny fragments are then cloned by the millions, cataloged and stored.

The gene library will make available the material needed for quick and accurate diagnoses of inherent medical problems. A researcher can look in the library for a sample of the gene linked to a particular disorder. The sample could then be compared to a test sample from a couple considering having children, a simple process that would determine the presence or absence of a defective gene.

So far, over 200 requests for library material have been made by hospitals, universities, and research institutions in over 30 states. Fifteen private U.S. biotechnology firms have also requested material. Plans are currently underway to establish an official repository for the library under the auspices of the National Institute of Health.

8. National Flow Cytometry Resource Transfers. The National Flow Cytometry and Sorting Research Resource (NFCR) at Los Alamos is a focal point for research in the areas of flow cytometry and cell sorting. Employees of NFCR and associated Los Alamos personnel engage in contracted and collaborative research with hospitals, other national laboratories, research organizations, and private firms.

An important function of the NFCR is to make research results and technology available to others outside the Laboratory. Software, schematics, instrument designs, procedures and/or samples have been distributed to more than 37 individuals from universities, private companies, or other research laboratories.

9. Magnetic Refrigeration. Research at Los Alamos demonstrated the practical application of magnetic refrigeration for cryogenic applications. The technology employs the special property of certain magnetic materials that spontaneously cool when an applied magnetic field is removed. This effect, coupled with developments in heat-transfer technology, led Los Alamos scientists to discover an efficient refrigeration method with potential cryogenic applications in optical imaging systems, space systems, health service technologies, and super computers.

The principal investigator worked on his own time with New Mexico's Technology Innovation Center at the University of New Mexico to develop a business plan to commercialize the new technology. Subsequently, the technology was transferred to Astronautics Corporation of American in Milwaukee, Wisconsin, along with four former Laboratory employees who took with them patent waivers from the Department of Energy for the technology. The company expects it will be at least two years before commercial versions of the new technology will be ready, but the increased efficiency of the new refrigerators should be at least twice that of comparable, existing refrigeration systems.

B. The Los Alamos Materials Technology Seminar

The Los Alamos Materials Technology Seminar was held at Los Alamos National Laboratory on August 27 and 28, 1985. American companies interested in obtaining access to recent major developments in materials technolgy at the Laboratory were invited to send representatives to the seminar to review new technologies and their potential for commercial development. The central purpose of the seminar was two-fold: 1) to stimulate opportunities for the appropriate transfer of technical know-how developed at the Laboratory to the US private sector for the benefit of the US economy, and 2) to promote interactions with private industry that compliment and enhance the technical base at the Laboratory.

The Los Alamos Materials Technology Seminar was the culmination of a pilot program called Quest for Technology. The goal of Quest was to find technologies, facilities, or expertise residing within the Laboratory that could by used by private industry. In this way the results of federally funded R&D can be made available to private companies to strengthen the national industrial economy and the Laboratory could strengthen its technical base and broaden its research perspectives through closer relationships with the private sector. QUEST was conducted in the Laboratory's Materials Science and Technology Division since it was felt that materials technologies were very likely to have commercial applications. QUEST identified 190 technologies, 90 percent of which were considered to be of commercial value. A subsequent market analysis of these technologies determined those QUEST topics that had the highest potential for commercial development. These technologies fell into four broad technical categories:

1. Radio Frequency Inductively Coupled Plasma Chemical Synthesis
2. Electrically Active (Conducting) Polymers
3. Silicon Carbide Whisker Reinforced Structural Ceramics
4. Low Density Biocompatible Polymer Foams

Synopses of all the QUEST topics were widely distributed to interested companies. Based on the responses for further information, five other technical areas emerged as also having high commercial potential:

5. Cobalt Free Nonconventional Hard Materials
6. Microwave Processing of Ceramics
7. Injection Moldable Ceramics
8. Closely Sized Test Sieves
9. Micrometrology Methods

A seminar covering these nine topics was determined to be the most efficient means of transferring detailed information to the many interested representatives from US industry. An announcement of the seminar appeared in the Commerce Business Daily on May 2, 1985. The response to the announcement was strong; more than 140 registration packets were mailed out resulting in 67 people attending the seminar representing 49 US companies (for a complete list, see Appendix A). The seminar program included technical presentations given verbally and in poster format, tours of relevant technical sites, and one-on-one private sessions where attendees could spend time with the Laboratory staff for in-depth discussions of the technologies and methods of transferring them to private industry. Costs associated with the seminar were covered by registration fees.

The long range benefits of the Materials Technology Seminar to the Laboratory and the the US private sector will not be known for some time. However, more than 40 serious inquiries for further contact or information resulted from the two days of meetings. Some of these contacts have already lead to substantive discussions of collaborative research projects, intellectual property rights, and reimbursable work for industry. For many people at the seminar, it was their first visit to Los Alamos or their first contact with the Laboratory. For them the seminar provided an excellent opportunity to learn not only about some of the technologies at the Laboratory, but also about the many ways in which the Laboratory is able to work with the private sector.

C. Hot Dry Rock Geothermal Energy Development Program Technology Transfer

The Hot Dry Rock Geothermal Energy Development Program (HDR) has focused worldwide attention on the facts that natural heat in the upper part of the earth's crust is an essentially inexhaustible energy resource that is accessible almost everywhere, and that practical means now exist to extract useful heat from the hot rock and bring it to the earth's surface for beneficial use. Under sponsorship of the

US Department of Energy and the governments of the Federal Republic of Germany and of Japan, the HDR program has successfully constructed and operated a prototype hot, dry rock energy system that produces heat at the temperatures and rates required for large-scale space heating and many other direct uses of heat. During the fifteen-year history of the HDR program at the Fenton Hill site outside of Los Alamos, it has been necessary to develop or support the development of a wide variety of equipment, instruments, techniques, and analyses. Much of this innovative technology has already been transferred to the private sector and to other research and development programs, and more is continually being made available as its usefulness is demonstrated.

During FY85, the Los Alamos administrators of the HDR program prepared a report outlining the extent of the technology transfer from the HDR program during the course of its development. The report does not specify when a transfer ocurred or to what company the technology was transferred, but it does include some valuable information. The means of transfer noted in the report include publishing reports and maps, contracted work resulting in an exchange of knowledge, direct transfers to private firms, and the creation of spin-off companies. In all, the report lists over twenty technologies that have been transferred in such areas as drilling techniques and tools, site exploration and characterization techniques, measurement techniques, hole-surveying instruments, and acoustic emmissions techniques, among others. A copy of the report is included as Appendix C.

D. The Los Alamos Small Business Center

The Los Alamos Economic Development Corporation (LAEDC) was incorporated in March 1983 to help stimulate diversification of the local economy (approximately 80% of the community's work force are employed at the Laboratory and virtually all of the remainder are indirectly supported by it). From its inception, the LAEDC was focused on developing the local economy by creating new businesses; the traditional role of the economic developer as a "smoke stack chaser" has been de-emphasized in the LAEDC. The primary source of new businesses has been identified as the potential entrepreneurs, currently employed at the Laboratory who have a Los Alamos National Laboratory-developed technology that has commercial potential. There are a number of local companies that began as Laboratory spin-offs. This fact seemed to indicate that Laboratory technologies make viable products and services for new companies to sell. The main purpose of the LAEDC, then, became to encourage and support the development and maturation of new Laboratory spin-off companies.

Having decided to emphasize small spin-off company development, the LAEDC began to formulate a strategy that would focus on services and activities that would be most supportive of these kinds of companies. The small business incubator seemed to be an ideal concept on which to base the LAEDC strategy, and therefore the LAEDC began to develop an incubator in October 1983. The LAEDC visited several existing incubators during the winter of 1983, and then decided to organize the first national incubator conference in April, 1984 so that the LAEDC and other interested communities could learn more about the various incubator models.

The Laboratory has been very cooperative in the LAEDC's effort to establish its incubator, called the Small Business Center (SBC). The Laboratory's industrial initiatives staff has been involved in the incubator since the LAEDC first studied it as a basis for small business development, and organized the effort to develop a seed capital fund. The Laboratory co-sponsored the incubator conference held in Los Alamos in April 1984, and the Laboratory's director has publicly endorsed and supported the SBC. The Los Alamos technology transfer programs, have placed a special emphasis on encouraging entrepreneurship. This is vital to the success of an incubator like the SBC that depends largely on the creation of spin-off companies.

The SBC opened its doors on February 1, 1985 and became the first small business incubator in the State of New Mexico. It currently houses 23 tenants, among which are a law firm, a personnel search service, and a technology transfer consulting firm, as well as the small high-tech and spin-off firms for which the SBC was originally devised. A brief report on the status of some of the new spin-off and high-tech tenants follows.

1. Mesa Diagnostics. During FY85, in a innovative joint venture, the Laboratory and Mesa Diagnostics Inc. cooperated in developing a potential method for rapid disease identification so that a commercial version of the Laboratory's prototype instrument can be marketed. This entrepreneurial program is the culmination of several years effort. In 1981, the Laboratory and the University of New Mexico co-sponsored a conference called "Financing Technological Innovation in New Mexico." One attendee was a former investment banker who had come to the Southwest to establish a venture capital fund based on technologies available in the region. As fund-raising neared its goal, he approached the Laboratory seeking an appropriate technology for a new business backed by venture capital. Multiparameter light scattering, a spin-off from the Los Alamos flow cytometry program, was an ideal candidate.

Multiparameter light scattering identifies viruses and bacteria through the interaction of light and the DNA molecules they contain. The helical structure of DNA molecules causes different kinds of light to scatter preferentially. Light of different wavelengths or polarization, for example, scatters in ways that provide unique signatures for disease-carrying viruses or bacteria. Because humans carry many harmless bacteria as well as those that cause disease, bacteria must be analyzed individually. Flow cytometry, which can narrow the flow of fluid to contain only a single bacterium at a time, provides such a capability.

Viral identification is simpler. Usually only one type of virus is present in the body and besides, viruses are the smallest biological particles. Scientists can therefore use chemical and centrifugal methods to remove all particles larger than viruses from a clinical specimen--sputum or blood, for instance--suspend the remaining viruses in a solution, and identify the type of virus by its multiparameter light scattering signature.

During FY85, the collaborators identified characteristic signatures for five closely related influenza viruses and discriminated between hepatitis and other viruses in a matter of minutes, instead of the hours previously required for such tests. They obtained similar results with bacteria, but only in static solutions containing a single type.

After advisors to the venture capital fund made a preliminary market survey, the Department of Energy negotiated a contract for private support of initial research leading to a pre-prototype instrument for identifying viruses and bacteria with the final goal of a similar intrument being made available to the market by Mesa Diagnostics, Inc. Mesa Diagnostics was a tenant in the SBC until construction of a new larger facility was completed.

2. AMTECH. AMTECH Corporation is a Laboratory small-business spinoff that combined several novel mechanisms in its establishment.

A Department of Agriculture-sponsored program in the late 1970s developed a passive method of electronic identification applicable to livestock. This passive circuitry required no power source and could provide both identification information as well as the animal's body temperature when "interrogated" by a nearby radio transmitter.

For several years, the Laboratory staff attempted to interest various instrumentation and equipment companies in adapting this technology for commercial use. The DOE made the underlying patents available for licensing for five years -- all with no success.

Convinced that this technology needed a "champion" to hurdle the barriers to commercialization, several of the program participants, who had since been reassigned in the Laboratory, began working on personal time to develop a business plan. They were assisted by a class project in the University of New Mexico's graduate course in Technical Entrepreneurship. They also applied to the Department of Energy and the University of California to grant them ownership of existing patents on the technology.

The process of preparing a business plan led them to other applications of the technology that appeared more attractive to the marketplace -- vehicle and rail car identification and warehouse inventory systems. By fall, 1984, they had obtained seed capital from a publicly-held computer software company. One scientist, the primary entrepreneur of this venture, left the Labortory in mid-1984 to devote full time to this venture. Two others were granted leaves-of-absence from the Laboratory to complete the commercial development of their technology, and two additional scientists are working part time for

AMTECH and for the Laboratory. AMTECH is located in the Los Alamos Small Business Center. When it outgrows these quarters, AMTECH will remain in northern New Mexico, contributing to a budding spirit of technology-based entrepreneurship in the Laboratory's neighborhood.

3. ICAMP. ICAMP began when a Los Alamos scientist left his job in metrology to start a business marketing software for coordinate measurement machines. While at Los Alamos, the scientist had developed analagous software strictly for Laboratory purposes. When he left to start ICAMP, it was necessary to rewrite the software for more general applications.

The software incorporates a solids modeler, which treats a part as a unified, mathematically-defined object rather than as a collection of independent geometric shapes. This feature allows the software to respond to data taken from any location on the part. It will find the location where the data was taken, change the graphic display, if necessary, and display the measured data. The computer, not the inspector, looks for the proper surface. This feature is especially important when one surface blends smoothly into another. With ICAMP's software, physical definition of a solid can typically be realized in less than half the time required to define an inspection program on most other current systems.

4. Newport Corporation. The Newport Corporation manufactures specialized laboratory equipment for electro-optical research. When Newport realized the market potential for developing new laboratory instruments based on technology from Los Alamos, it decided to set up a small, engineering development group in the Los Alamos Small Business Center.

The first step was finding a local representative to head the Los Alamos office for the firm. To fill this position, Newport hired a Los Alamos scientist who was familiar with Newport products. The scientist left his job at the Laboratory to take the position. Currently, Newport is engaged in engineering development utilizing its new laboratory space in the SBC.

E. Collaborations with Industry

1. New Collaborations (1985)

a. The Thermal Insulation Manufacturers Association funded a study by Los Alamos personnel on the toxic effects of asbestos and other insulating materials.

b. Los Alamos entered into a research collaboration with Agracetus Laboratories, a partner in research with W. R. Grace, during FY85. According to the agreement, Los Alamos would continue its efforts at isolating and characterizing gene promoters responsive to changes in environmental concentrations of certain trace metal ions. Upon isolation and characterization of the promoters, Agracetus would help to characterize and map the promoter sequence by supplying the necessary transformation vectors and gene expression system to functionally assay the different parts of the promoter. Because Los Alamos does not have the expertise, in house, to accomplish these tests, the collaboration is beneficial to us. Should the gene promoter have practical utility, Agracetus would have the first vectors containing this promoter. Should the promoter sequence become of more interest, Agracetus is willing to pay for its development and continued use.

c. FY85 marked the beginning of a long-term research collaboration with Pioneer Hybrid. The collaboration involves the isolation and cloning of chromosome specific DNA fragments from maize. Because maize is such an important crop species and because, while large numbers of genes have been mapped, the mechanisms behind these genes are not well understood, it is useful to develop a pool of chromosome specific molecular markers for use in corn genetic and breeding studies. Los Alamos has the means to characterize and sort large numbers of purified chromosomes. However, the need for a source of large numbers of chromosomes with which to work required that a collaborator be sought. Pioneer Hybrid is the largest producer of seed corn in the world. As such, they have extensive expertise working with maize. In order to obtain large numbers of chromosomes, well synchronized cell cultures capable of rapid cell division are required. In collaboration with Pioneer scientists and utilizing proprietary corn cell lines and proprietary techniques, the scientists are on their way to developing such cell cultures. Without the collaboration, Los Alamos would not have made progress in this area. Pioneer will benefit by the availability of chromosome specific maize libraries and will have first use of the libraries by virtue of the fact that they will characterize and determine the quality of the libraries prior to general release.

d. Los Alamos entered into a cooperative agreement with Scientific Calculations, Inc. during FY85. The purpose of the collaboration is to study the benefits of artificial intelligence (AI) for computer-aided design (CAD) efforts. According to the agreement, Scientific Calculations provides Los Alamos with its state-of-the-art CAD software for use in the study. In return, the Laboratory provides Scientific Calculations with the results of the research.

2. Ongoing Collaborations

a. An employee of Armco, Inc. continues to work with Los Alamos personnel on the development of a laser-based device for the in-process analysis of molten metal. The joint study is funded by the DOE and twelve companies of the American Iron and Steel Institute, a steel industry consortium.

b. The Honeywell Secure Communications Processor (SCOMP) is a multilevel security computing system that provides segmentation, paging, and protection rings to separate various levels of security classifications. This multilevel-type system is very important to DOE and DOD because it allows processing of various levels of classified data in one machine. One machine does not need to be dedicated to one level of classification and all personnel do not have to have security clearances in order to use the machine.

Honeywell and Los Alamos entered in a joint agreement in January, 1984 that remained active through FY85. According to the agreement, Honeywell provided Los Alamos with a SCOMP to test and evaluate. In return, Los Alamos provides evaluation reports to Honeywell on the performance of the SCOMP.

III. STATE GOVERNMENT/LABORATORY INTERACTIONS

The Los Alamos National Laboratory is actively involved with the New Mexico State Government in the development of the Rio Grande Research Corridor project, an initiative to harness the State's vast technological resources for economic growth and diversification in New Mexico. Los Alamos is working closely with the other federal laboratories and research institutions in the State, the State University System, private companies, and State government agencies to promote the use of these resources in New Mexico by new and existing businesses to stimulate technological innovation and growth in the private sector.

During FY85, the Laboratory contributed the following technical and managerial assistance to the State of New Mexico.

A. Membership on Boards and Commissions.

Staff and management from the Laboratory have served on:

New Mexico Science and Technology Advisory Committee;
New Mexico Economic Development Board;
New Mexico Energy Research and Development Institute's Board of Directors and Technical Advisory Board;
New Mexico Technet, Inc.;
New Mexico Industrial Development Executives Association;
New Mexico Industry Development Corporation;
Tri-Area Association for Economic Development;
Los Alamos Economic Development Corporation.

B. Loaned Executives to State Government.

The Laboratory has provided technical and administrative management assistance to the New Mexico Department of Economic Development and Tourism to develop and implement several Rio Grande Research Corridor initiatives. Presently, a Laboratory manager is working with the Department on loan under an I.P.A. agreement that allows full cost recovery from the State.

C. Technical Assistance and Evaluation.

The Laboratory attempts to provide professional technical advice and assistance to State agencies when local expertise is not available. Such assistance generally takes the form of providing technical evaluations of proposals to the Energy and Minerals Department, the Energy Research and Development Institute, or the Technology Innovation Center.

IV. LOS ALAMOS COMMUNITY RELATIONS PROGRAM

The goal of the Los Alamos Community Relations program is to establish a good neighbor policy between the communities of northern New Mexico and the Laboratory by strengthening existing relationships and establishing new ones with community leaders and groups.

A. Educational Outreach

One major component of this program consists of a series of educational outreach programs that are designed to: 1) meet the national need for a reemphasis on math and science by increasing public understanding of current scientific research and by encouraging young people to consider careers in science; and 2) develop human resources in New Mexico by meeting the need for a technically trained workforce. Several different programs have been developed to target students from grades 4 through 12. Our programs are dynamic and exciting, and they reach over 10,000 students in seven counties of northern New Mexico.

The following is a brief summary of each program.

1. Science Beginnings. A "gee whiz" program for elementary students (Grades 4-6), designed to stimulate children's imagination and interest in science.

Twenty-seven schools were visited by Laboratory personnel during the 1984-85 school year. Approximately 1,800 students were involved in the program.

The Bradbury Science Museum was the site for 10 Monday morning programs, developed to feature experiment based, hands-on demonstrations.

2. Careers in Science. A role-modeling program designed to familarize junior high school students (Grades 7-10) with a full range of science and technical careers.

Thirty-nine area schools were visited from September, 1984 to May 1985 by panels of 3-5 Laboratory employees. A total of 153 presentations were given to over 7,000 students. Other special requests and programs that were a part of the Careers in Science

Program included: visits by a variety of organizations to the Bradbury Science Museum; assistance with teacher workshops; assistance with science fairs; and speakers sent for special assembly programs.

3. Los Alamos Science Student Program (LASSP). A program created for motivated high school juniors and seniors to take courses at the Laboratory taught by Laboratory employees who volunteer their time to teach state-of-the-art technology.

Thirteen courses were offered during both the Spring and Fall semesters. A total of 104 students from Los Alamos, Espanola, Pojoaque, Santa Fe, Jemez Valley and Taos High Schools participated in the program. Eighty percent (83 students) completed the program and were recommended to receive school credit.

4. Los Alamos Summer Science Student Program. A program developed for talented high school seniors who wish to work within a scientific environment to design, construct and present a science project.

Twenty-five high school juniors and seniors from eight northern New Mexico High Schools participated in the six week program.

5. Los Alamos Summer Science Teachers Institute (LASSTI). A program established in 1984 to help teachers provide enrichment to their classes by providing them with new knowledge and Laboratory techniques.

In 1985 a four week course offered lectures, demonstrations, laboratory work and tours for mathematics and computer science teachers. The lectures were presented primarily by volunteers from the Computing Division and from the Theoretical and Applied Physics Division.

Twenty teachers from secondary schools in the seven northern counties of New Mexico participated in the program, with an option to apply for four hours of college credit.

Two LASSTI follow-up workshops were held during the fiscal year for participants in the 1984 summer program to extend and reinforce their learning experiences.

6. Science Youth Days. Science Youth Days is a program that provides students with an opportunity to visit the laboratory and participate in tours, lectures, scientific demonstrations and hands-on laboratory experiences.

For the 1985 program, Los Alamos National Laboratory hosted the 29th international Edison Birthday Celebration Symposium from April 10-13. There were 75 students and accompanying teachers or industry representatives from across the united states and from five foreign countries. There were over 750 participating students from New Mexico, Texas, Colorado, Arizona and California.

7. Evaluation. In order to assess the impact of the educational outreach programs, the Laboratory has conducted an evaluation of the programs. The findings suggest that the programs are having an impact in two major areas: 1) they are encouraging students to take an interest in science and technical careers; and 2) they are having a significant positive influence on the image of the Laboratory in northern New Mexico.

B. Community Outreach

The second major component of the Community Relations Program consists of four programs that are intended to "bridge the gap" between Los Alamos National Laboratory and the communities of northern New Mexico. Two of the programs were new initiatives in 1985. The following is a brief summary of each program.

1. Retired Volunteer Services Program (RTVS). A program that matches community projects in need of help with available and interested retired volunteers who have relevant expertise.

The RTVS, having completed its first full fiscal year, has 56 volunteers. Almost half of them donated time to a wide variety of programs and organizations. Six projects are ongoing assignments involving eight volunteers.

2. Volunteer Service Program. A new initiative that utilizes Laboratory Employees who are willing to give their free time to assist a variety of individuals and/or organizations in northern New Mexico.

There are 324 Laboratory employees who have indicated a desire to participate in the Volunteer Service Program. Their expertise lies in the following areas: Science/Engineering; Construction; Business Administration/Office work; Communications/Computing; Education; Environment; Health/Medical Services; Law Enforcement/Security; Library Services; Arts/Crafts; Languages; and Recreation/Sports. In the beginning months of this program, 19 referrals have been made. An increase of activity is expected during the coming months as the various agencies become aware of our available volunteers.

3. Speaker' Bureau. A program that sends experts in their fields to speak to service organizations, colleges and universities around New Mexico, as requested.

Our current roster of Laboratory speakers numbers 228. Twenty two speakers went to a variety of schools, colleges and organizations in New Mexico, Texas, Arizona, Colorado and California. Talk covered such topics as energy technologies, Monte Carlo methods, artificial intelligence, strategic defense initiatives, computer graphics and neutron scattering.

4. Equipment Loan Program. A new initiative in 1985 is a program that loans Laboratory equipment to public high schools -- equipment

that is not ready for salvage but not in use at the Laboratory. Loans can be made for up to a one year period and then extended if not needed immediately.

Thirteen schools out of 19 contacted requested a variety of equipment and 64 items have now been loaned to those schools.

5. Other. Other activities of the Community Outreach Office included: Coordination of the Christmas Drive; coordination of Laboratory sponsored activities for National Hispanic Heritage Week; numerous presentations to school boards, city and county governments, pueblo council meetings, and community groups; assistance and participation in organizing the New Symposium on Resources in Math/Science Education; coordination of and participation in Los Alamos National Laboratory Community Council; participation in American Indian Task Force; and participation, as member of the Board of Directors, in the National Association for Corporate Speaker activities; and a member of Board of Directors for the New Mexico Community Foundation.

As of the end of FY85, both components of the Community Relations program have a total of 1041 Laboratory employees and 56 Laboratory retirees who have participated or are willing to participate in the program. Program administrators have recently completed a database that contains this information to facilitate utilizing these volunteers.

V. UNIVERSITY/LABORATORY PROGRAMS

Los Alamos National Laboratory continues in its commitment and dedication to fostering collaborative arrangements with the academic community in order to take advantage of the synergistic effects that such arrangements provide, benefiting both the Laboratory and the universities.

We now maintain formal consulting and collaborative agreements with more than 1000 faculty or staff from nearly 300 colleges and universities throughout the United States and around the world. In addition, 335 undergraduate students and 183 graduate research assistants were employed by the Laboratory in 1985, together with 98 postdoctoral appointees. These, together with 24 students from Historically Black Colleges and Universities, and 77 military service academy associates, give an indication of the efforts the Laboratory expends in its concern for educational support.

In addition, the Laboratory participates in the DOE-sponsored Laboratory Cooperation Program, particularly in our long-time relationship with Associated Western Universities (AWU), a consortium of universities. During FY 1985, 49 students and faculty of AWU member universities held thesis research, graduate assistant and faculty appointments at Los Alamos; an increase of nearly 50% over the previous year.

There is a growing number of interactions between Los Alamos staff and University of California faculty, staff, and students. Triggered in large measure by the establishment of a branch of the Institute of Geophysics and Planetary Physics at Los Alamos in 1980 and by a large representation of University of California researchers on the users' group of the Los Alamos Meson Physics Facility (LAMPF), interactions increased among nearly all Los Alamos divisions and all of the nine University of California campuses. During the past year, the Laboratory and the University of California have mutually agreed to begin a formal internship program, allowing undergraduate and graduate students to work at the Laboratory in an ongoing program beginning at the sophomore year and continuing through the master's degree. We expect this internship concept to provide even greater opportunities for contact and collaboration between Los Alamos divisions and University of California departments, particularly in the engineering sciences.

Close ties with academic institutions in New Mexico are an important and continuing interest of the Laboratory. University of New Mexico (UNM) has operated the Center for Graduate Studies for the past 29 years, providing residence credit programs leading to the MS and PHD degrees. Beginning in the winter of 1985-86, interactive video links between the Laboratory and the UNM campus will be in operation, increasing the effectiveness of the Graduate Center.

The strong collaborative research programs already in place between the Laboratory and UNM, particularly in the establishment of the Noninvasive Diagnostic Center, in joint research programs between the Life Sciences Division at Los Alamos and the UNM medical school, and collaboration between the UNM Materials Science Center and the Laboratory's Center for Materials Science, are continuing to grow.

We also maintain strong ties with New Mexico State University (NMSU) and the New Mexico Institute of Mining and Technology (NMIMT), particularly in our support of "Centers of Excellence" at those institutions as an initiative of the Rio Grande Research Corridor project: Computing and Plant Genetics at NMSU, and Explosives Technologies at NMIMT. As an example, Los Alamos has joined with Sandia National Laboratories, Albuquerque, NMIMT, and UNM to form a Consortium for Explosives Technology to foster technology transfer to industry and to provide closer ties for collaborative research in explosives science.

A further initiative involving Los Alamos National Laboratory and the major academic institutions of New Mexico is the recent creation of the Rio Grande Technology Foundation (Riotech). Riotech is a nonprofit corporation composed of the government laboratories in New Mexico; NMSU, NMIMT, and UNM; and a number of private sector corporations. Its purposes are to strengthen education in sciences and engineering using the talent of the national laboratories and to foster collaborative research and development that might have possibilities for technology transfer to the private sector.

Such three way interactions may be difficult to arrange and administer, but we consider the Riotech concept to be an innovative way to promote excellence in education and encourage tranfer of technology into marketable products utilizing cutting-edge technology of the national laboratories.

In summary, the Laboratory continues to encourage interactions of all kinds, not only with our parent institution, the University of California, and local institutions in New Mexico, but with universities throughout the country. We have ties of one kind or another to more than 300 universities. The LAMPF Users' Group is, of course, the largest and one of the oldest examples of formal collaboration; we have very successful internship program in place with the Massachusetts Institute of Technology (MIT), and we have identified 33 Laboratory facilities and major equipment items that are available to users in the universities and private sector. The newly completed Proton Storage Ring, a part of the Los Alamos Neutron Scattering Center, which should rapidly become an international center for neutron scattering experiments examining the basic structure of materials, will add to our collaborative and cooperative research programs. All in all, several hundred significant interactions among Los Alamos staff and university faculty and students occur each year; including LAMPF, about 6% of our annual operating funds are spent on university/Laboratory programs. In addition to the California and New Mexico universities previously mentioned, the institutions with which we have significant interactions include the Universities of Arizona, Texas, Colorado, Wisconsin, Chicago, and Indiana, together with Stanford, Cornell, Columbia, MIT, and Cal Tech.

VI. ISSUES

The Laboratory's industrial initiatives have both external and internal goals. On a national basis, the external goals are to help effect the optimum use of Laboratory technology by industry in order to contribute to the nation's industrial strength and to strengthen the Laboratory's science and technology base. The regional goal is to provide appropriate technical assistance to state government, private industry, and other regional entities.

The internal goals are to strengthen the value of the Laboratory's applied programs through early and sustained collaboration with the ultimate developers and suppliers of the resulting technology and to enchance the scientific, technical, and leadership vitality of the staff through collaboration with industry and others. Six issues are central to the effectiveness of the Los Technology Tranfer Program. Each is discussed in the following sections.

A. Industry Liaisons

To establish beneficial liaison with industry, the strategy is to work simultaneously on development of Laboratory interest, industry contacts, and methods for cooperation, and on identification and reduction of barriers. Companies are targeted nationwide to develop liaison in both technology and programmatic areas, typically through invited visits with Laboratory personnel and follow-up in specific technical areas. Work with small business is focused regionally, with particular attention to cooperation with the University of New Mexico's Technical Innovation Center, the Los Alamos Economic Development Corporation, existing small businesses, and interest in the spin-off of companies locally to exploit Laboratory technology.

The interest, cooperation and assistance provided by DOE Albuquerque Operations Office have been very valuable in establishing working relationships between the Laboratory and industry. The ability to expedite requests for contract work for industry is often essential to industry's needs in commercializing technologies developed at the Laboratory.

B. Patents and Licensing

The ability to obtain exclusive or semi-exclusive license to federally developed technologies continues to be an important factor in transferring technology to the private sector. Federal legislation and agency policies on this issue over the past few years have made a significant impact on the Laboratory's technology transfer effort. Both DOE and DOE contractor policies in this area are the subject of much ongoing discussion. The Laboratory will follow these discussions closely and their effects on the Laboratory's ability to transfer technology to industry.

C. Federal Laboratory Consortium (FLC)

Through active participation in the FLC network, the Laboratory is able to draw upon the unique expertise of other federal laboratories in addressing requests for assistance and is conversely a resource to entities outside its geographical region. For the past four years, Los Alamos Industrial Initiatives Officer, Gene Stark, has served as Chairman for the FLC.

Legislation regarding the FLC and its role in facilitating transfer of technologies out of federal laboratories is presently pending before Congress. Results of this legislation could significantly affect the FLC and the role Los Alamos might play in FLC activities of the future.

D. Information Development

Although most information dissemination is passive and yields little direct technology transfer, it can have an important role in establishing personal contacts from which productive transfer can result. Information targeted directly at potential users (for example, trade journal articles and distribution of applications assessments) has particular emphasis; professional publications, press releases, and the magazine Los Alamos Science also have an important role.

E. Internal Laboratory Motivation

The Laboratory is developing motivation and interest within the Laboratory's staff and management in technology-transfer-related activities; has instututed an ongoing inventory of new ideas, technologies, and research results for review and transfer; and provides an environment that encourages working-level staff to propose and pursue technical initiatives with industry.

F. Individual Entrepreneurship

A growing body of local interest and experience and national policy is strengthening significantly the role of individual entrepreneurs in commercial applications of Laboratory technology.

VII. APPLICATION ASSESSMENT

Los Alamos continues to follow the approach taken previously to perform detailed, highly visible inventories of technologies ready for application to industry's needs. FY85 saw the completion of the pilot Quest for Technology Project (see section II.B.), and the routine application of the Quest inventory to other divisions of the Laboratory has begun. Likewise, Los Alamos seeks to participate in National Technology Transfer Conferences and other fora where highly focused presentations on selected technologies can be made to interested industry.

Appendix A. Companies Participating in the Los Alamos Materials Technology Seminar

Allied Corporation
General Electric
Stauffer Chemical Co.
Preform Sealants, Inc.
Union Carbide
Carpenter Technology Corp.
AVCO
Gulton Industries
GV Medical, Inc.
Carbomedics, Inc.
Boeing Aerospace Co.
Dow Chemical Co.
Cabot Corp.
Ethyl Corp.
Gould Research Center
Texas Instruments, Inc.
Rockwell International
RCA Laboratories
Dresser Industries, Inc.
Versar Manufacturing, Inc.
MRI Ventures, Inc.
Vasco-Pacific
Martin Marietta Aerospace
Hercules, Inc.
AiResearch Manufacturing Co.
Advanced Refractory Technologies, Inc.
GTE Laboratories
St. Jude Medical
Shieldalloy Corporation
Meadox Medicals, Inc.
KMS Fusion
Aluminum Company of America
3M
Boeing Military Airplane Company
Sohio Engineering Materials, Inc.
Johnson & Johnson
GTE Products Corporation
Eagle-Picher Industries
David & Geck
Borg-Warner Chemicals
Air Products & Chemicals, Inc.
National Starch and Chemical Corp.
American Cynamid
Drackett Company
Watkins-Johnson Company
Martin Marietta Energy Systems
Pittsburgh Corning
CVD Incorporated
United Technologies

Appendix B. Technology Transfer Program Plan

Los Alamos presently devotes two full-time professional staff and one full-time support staff to the Industrial Initiatives program at the Laboratory. However, day-to-day technology transfer and industrial liaison activities within the Laboratory are estimated at ten times that level. This level of effort is projected to be constant for the next five years. (See Table 1 below)

The professionals responsible for the industrial initiatives functions report to the Assistant Director for Industrial and International Initiatives. Because the technical resources for these functions are spread throughout the Laboratory, there are formal lines of communication with virtually every level of management in both discipline and program, weapons and nonweapons areas. There is specifically assigned legal support for this function in the Patent Law Group.

Funding	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
($ in thousands)						
Industrial Init.	300	300	300	300	300	300
Other (estimate)	5200	5200	5200	5200	5200	5200
Total	5500	5500	5500	5500	5500	5500
Staffing						
(in FTEs)						
Professional Staff						
Industrial Init.	2	2	2	2	2	2
Other	20	20	20	20	20	20
Total	22	22	22	22	22	22
Support Staff						
Industrial Init.	1	1	1	1	1	1
Other	10	10	10	10	10	10
Total	11	11	11	11	11	11

Table 1. Estimated Resources: Personnel and Funding in FY85 Dollars

Senator **Domenici**. Thank you very much, Dr. Hecker.

Mr. Welber, we welcome you here. Publicly, let me say we're delighted that you join us here as President of Sandia. We're very proud of what you do there and we look forward to your testimony.

Mr. **Welber**. Thank you very much, Senator Domenici. I really didn't think I had a choice. [Laughter.]

Senator **Domenici**. Well, you might not have had a choice here, but there could have been some other choices somewhere else. [Laughter.]

Mr. **Welber**. Senator Domenici, Senator Bingaman, and Congressman Lujan, I think it's going to be a pleasure to testify. [Laughter.]

Before I start, though, I'd like to say that this has been very useful to me because I think what we're seeing here today is the impact of the rapid advance of technology on our society. As an example of this, about 10 or 12 years ago I bought a—my company bought for me a pocket calculator, and they paid $450 for it. Today, I can get a calculator that does as much if not more with a 1-year subscription to Time Magazine, and I get it free. Now, that is really advancing technology. And we in the national laboratories are trying to do our best to keep that going.

What we're seeing here is that the impatience of the scientists and engineers who are helping to achieve this advance, their impatience at seeing these advances getting into our society and into industry, and that impatience is reflected in some of our testimony. However, we must balance that against the mission of the national laboratories, which is the defense of our country, and we do classified work and much of what we do cannot be easily brought into industry. But much of what we do can. And we are working very closely with the Department of Energy to achieve administrative processes to allow this to happen more gracefully and more rapidly. More importantly, I want to reassure you that these hearings are going to be very beneficial in expediting those administrative processes.

However, in my testimony I emphasize the necessity for legislative action, and Sandia's involvement with technology transfer broadened very much during the energy crisis of the mid-Seventies. Our activities now include giving information and assistance and arranging personnel exchanges, sharing facilities and seeking areas in which laboratory skills can benefit America.

As an example of some of the discussion that we were having earlier with the earlier witnesses, of using some of the technology that was created in weapons development, we are using some of that technology which uses lasers to examine the process of a nuclear explosion. That same technique is used to examine the process of the internal combustion engine. We have created at Sandia-Livermore a combustion research facility which is shared with industry to better understand how to make our engines more efficient and more competitive.

Patents are an important incentive in the innovative process. Obtaining patents has a positive influence on the enthusiasm of technical people to make and document inventions. Patents also encourage the investment needed to bring inventions to the marketplace.

Congress has already recognized the value of patent incentives for encouraging commercialization of federally funded inventions. Congress enacted legislation giving patent rights to universities and small businesses working under Government contracts. In particular, the Bayh-Dole Act and its amendments enable small business and nonprofit contractors, such as universities, to automatically obtain exclusive rights to inventions made in the performance of their work.

The University of California, for example, can own patents to inventions made at the Lawrence Berkeley Laboratory. This encourages the university and the Lawrence Berkeley Laboratory to assist in the commercialization of these inventions.

Two exceptions to Bayh-Dole inhibit technology transfer efforts of some of our Nation's largest laboratories. The first exception is that weapons-related laboratories of the Department of Energy are expressly excluded. Thus, Sandia, Los Alamos, and Lawrence Livermore National Laboratories are excluded from Bayh-Dole.

The second exception excludes laboratories that are operated by large, for-profit business. This provision excludes Sandia, operated by AT&T, as well as another major laboratory, Oak Ridge National Laboratory, operated by Martin-Marietta. Ironically, AT&T, a large for-profit business, operates Sandia, but receives no profit or fee. Nevertheless, the Bayh-Dole exception applies.

What I would like to conclude with is a statement of what I believe will summarize what I have heard here today. We, the national laboratories, with the DOE, should continue to examine more carefully administrative processes which could expedite technology transfer. Second, more progressive and uniform laws applicable to inventions made at national laboratories would enhance the commercial benefits of our work, which has been so importantly pointed out, at no additional cost. Indeed, if some of the royalties were returned to the laboratories, it could be a savings to the taxpayer. Third, the patent royalties could be used to support the programs at the laboratories. Finally, I believe, with the proper administrative processes, we could do this with no security risk.

Thank you for this opportunity to share with you some of my thoughts.

[The prepared statement of Mr. Welber follows:]

TESTIMONY

OF

MR. WELBER

AT THE

JOINT CONGRESSIONAL HEARING

ON TECHNOLOGY TRANSFER

SEPTEMBER 4, 1986

It is a pleasure to appear before this committee on the important subject of technology transfer. I will report on successes in technology transfer at Sandia National Laboratories and suggest some ways in which the process may be improved.

Technology transfer has long been a focus at Sandia because we work very closely with industry and universities in carrying out our national defense missions. At the same time, we recognize that our national interest extends beyond national defense. Our national priorities must include economic competitiveness. And economic competitiveness is closely linked with technical developments.

Sandia's involvement with technology transfer broadened during the energy crisis of the mid-seventies. Our activities now include giving information and assistance, arranging personnel exchanges, sharing facilities, and seeking areas in which laboratory skills can benefit America. Technology born at Sandia now is saving the nation hundreds of millions of dollars annually in energy costs. Sandia's 1985 Report on Technology Transfer shows the wide spectrum of our activities in energy and other fields. Copies of the report are available here. Copies are also available from Sandia upon request.

Although we are proud of the impact of our technology transfer, we can suggest ways in which our program might be enhanced. I will comment here primarily upon patents.

Patents are important incentives in the innovation process. Obtaining patents has a positive influence on the enthusiasm of technical people to make and document inventions. Patents also encourage the investment needed to bring inventions to the marketplace.

Congress has already recognized the value of patent incentives for encouraging the commercialization of federally funded inventions. Congress recognized that technology transfer using patents is best done by the inventing organizations. Inventing organizations have the incentive and expertise to be good advocates and market creators for laboratory technology.

Congress enacted legislation giving patent rights to universities and small businesses working under government contracts. In particular, the Bayh-Dole act and its amendments enable small business and non-profit contractors, such as universities, to automatically obtain exclusive rights to inventions made in the performance of their work.

The University of California, for example, can own patents to inventions made at the Lawrence Berkeley Laboratory. This encourages the university and the Lawrence Berkeley Laboratory to assist in the commercialization of inventions.

Two exceptions to Bayh-Dole inhibit the technology transfer efforts of some of our nation's largest laboratories.

The first exception is that weapons-related laboratories of the Department of Energy are expressly excluded. Thus, Sandia, Los Alamos, and Lawrence Livermore National Laboratories are excluded from Bayh-Dole.

The second exception excludes laboratories that are operated by large "for-profit" businesses. This provision excludes Sandia, operated by AT&T, as well as another major laboratory, Oak Ridge National Laboratory, operated by Martin-Marietta. Ironically, AT&T, a large "for-profit" business, operates Sandia, but receives no profit or fee. Nevertheless, the Bayh-Dole exception applies.

If Congress intends to fully utilize the potential of patents to spur technology transfer, the law should be changed. The weapons-related exclusion in Bayh-Dole should be eliminated. Also, large "for-profit" contractors that operate national laboratories without profit or fee should be treated in the same way as non-profit contractors.

In making this suggestion, I wish to emphasize that extending Bayh-Dole must in no way detract from the defense mission of our national laboratories, which is paramount, or diminish the excellent communication that now exists within and between our national laboratories. I believe that working with our government sponsors, we can prudently implement an extension of Bayh-Dole to avoid such problems.

The legislation could provide that royalties received by large firms in licensing technologies developed at government-owned laboratories could be returned to the laboratories to fund laboratory programs. Large firms that operate federal laboratories should be able to negotiate reasonable royalty arrangements with other parties to encourage commercial development of laboratory technology. Such arrangements might include plans for commercialization. If expectations fail, there could be provisions that would give another company the chance to take over the invention.

I am also aware of the concern that extending Bayh-Dole might encourage premature disclosure of sensitive information to the detriment of national security. Here again, I believe that extension of Bayh-Dole, properly managed, will avoid this concern.

We have forty years of experience working in partnership with our government sponsors to establish and enforce rules for the control of sensitive information, classified as well as unclassified. This effort includes controlling the dissemination of information which may influence the national security. Emphasis on technology transfer at Sandia National Laboratories has not compromised security in the past. I am confident that extending Bayh-Dole would not do so in the future.

On the other hand, we can more effectively use ideas that are patented to strengthen U.S. industry. It is widely acknowledged that economic strength is a necessary partner to military strength in national security. Under the present system, however, unpatented information is available to anybody, including our international rivals.

I have been discussing the use of patents to promote technology transfer. Copyrights also are a useful tool, particularly for innovations in software. Consideration also should be given to providing exclusive copyrights to the laboratories to promote technology transfer.

In closing, let me summarize some key points:

- First, more progressive and uniform laws applicable to inventions made at national laboratories would enhance the commercial benefits of our work, at no additional costs -- indeed, at savings -- to the taxpayer.

- Second, the patent royalties could be used to support programs at the laboratories.

- Finally, the changes in the law would pose no security risks.

Thank you for this opportunity to share with you Sandia's experiences in technology transfer.

Senator DOMENICI. Thank you very much, Mr. Welber.

Let me just start off by asking you, should the exception to the Bayh-Dole legislation be removed? Should we get rid of it and should we treat the weapons labs exactly as we treat the rest of them under Bayh-Dole or not?

Mr. WELBER. I would like to try to see if we could, with the Department of Energy, create proper administrative processes so that those restrictions that presently exist on the weapons laboratories could be removed to help us expedite technology transfer.

Senator DOMENICI. It seems to me that Senator Bingaman inquired of the so-called Solomon amendment. From what I read, it's a step backward from what you have just described, in that it would channel all of that back through some central bureaucracy at the national level rather than rely upon some more diffuse decision with reference to the appropriateness of the application to patent or transfer.

Do you agree?

Mr. WELBER. I believe that the Solomon amendment would require that all waivers be agreed to by the military liaison commission as well as the DOE, and this introduces another interface, another decisionmaking process, which would slow things down without question.

However, I believe that the activities at the national weapons laboratories entail three areas of technology. One is clearly classified, about which there is no question. Second, it is clearly unclassified and has national importance and can be used commercially. It's that third gray area between those two which causes us to have administrative difficulty. I believe if we could arrive at guidelines so that the questionable area could be well delineated, we could get rid of some of this kind of administrative interface delay.

Senator DOMENICI. I have some additional ones, but let me go ahead and yield. Congressman Lujan.

Mr. LUJAN. Thank you very much.

You know, the laboratories are unique in the things we're talking about, because it's interesting, Dr. Hecker, about, you know, the different kinds of technology transfer, the pull and all those. I guess we tend to focus on the entrepreneurial types of spinoffs through technology transfer, but those others are very important.

I guess, you know, the significant part of the two of you being here, at least as far as New Mexico is concerned, is that you both are relatively new as directors of the laboratories, and while, you know, good efforts have been made all along to move ahead with technology transfer, we still have a lot of—we still have a lot of problems of getting it out there.

It's kind of frustrating. We all agree what we must do and certain—let me tell you I certainly agree that the primary mission is the defense aspects, that all of these things are secondary. But there's a frustration, that we just having got a handle on how properly to do it. I guess maybe that's it. And with the two of you as almost brand new and as directors, it's an ideal position for you to move on ahead.

Let me develop a line here. Have the laboratories—and that's to both of you—made requests for individual or class waivers under the DOE's new policies? Have any requests been made yet?

Dr. **Hecker**. As was pointed out, Congressman Lujan, at this point the laboratories do not qualify for the class waivers. And so we've handled all of the requests for waivers on a petition basis.

Mr. **Lujan**. But you have made some requests?

Dr. **Hecker**. Oh, certainly the requests have been made on a petition basis, and many of those—in fact, most of the requests that have been made have, indeed, been granted. However, as was pointed out earlier, one of the problems with the current system is the fact that it is very time consuming and cumbersome——

Mr. **Lujan**. That was the policy. How long?

Dr. **Hecker**. It's been a long process, and I'm not sure I have exactly at my fingertips the average length. But certainly a year is probably close to the average of what it takes to get a petition through and to get the waiver granted.

Mr. **Lujan**. Does that tend to discourage the companies that are seeking it?

Dr. **Hecker**. That, of course, is indeed the Achilles' heel of transferring to the entrepreneurial sector. The private sector needs to move quickly in order to have the economic incentive. And if we don't move quickly, we lose that incentive and that's been the bulk of our problem. As Dr. Welber pointed out, the problem with really transferring, and the problem with the administrative procedures is such that they are very lengthy.

Mr. **Lujan**. Can either one of you just give a ballpark figure, or if you don't have it, provide it for us, of how many of these waivers have been granted and how many denied?

Dr. **Hecker**. My recollection is that, in the past 5 or 6 years, we've had on the average of 40 patent applications—I'm sorry, 40 patents granted—and about 10 on the average a year that we've requested the waiver for. And I would say approximately 80 percent or so of those waivers are granted.

Mr. **Welber**. I would say that I learned just last night that the situation is improving. Don Oftey told me that a waiver was granted in 9 days yesterday. So that things can happen more quickly. However, our experience up to now has been very similar to what Sig pointed out. The numbers are in the tens or less, and it takes a long time.

What happens is that, in frustration, some of the engineers and scientists who are prevented from publishing until a patent is obtained, if they are applying for one, tend not to want to apply for a patent in order to be able to publish it. Once you publish, it's available to everybody.

Mr. **Lujan**. Was it just coincidence that that came about in 9 days the day before this conference? [Laughter.]

Mr. **Welber**. I would be hard pressed to say, and it would be very inadvisable for me to say. [Laughter.]

Senator **Domenici**. If we asked them, they wouldn't admit it.

Mr. **Lujan**. Well, maybe not, you know. Who knows.

Why does it take so long? Is it lack of money, lack of procedures set up? Are there other aspects that maybe we could deal with, that you could deal with maybe administratively, or that we could deal with, as far as the law is concerned? Could we give you more money to——

Mr. **Welber**. Well, I can give you an example of one of the problems, of a recent application we had. Since Sandia is operated by a company for no profit or no fee, the only resources we have come from the DOE. If we want to pursue a patent application, we cannot use DOE money to do that. So we are essentially hamstrung in applying for a patent, at least spending money to apply for a patent, because we are prohibited from spending Government money for a patent waiver for an individual or for a company. So we're working with DOE now to use perhaps some of our technology transfer funds, half a percent of our budget which can be used for that purpose. That's in the kind of administrative process which can help us over some of these hurdles which exist today.

Mr. **Lujan**. Wait a minute. Let's back up a little bit.

You say you don't have any money to apply for the patents. Don't you go to DOE and say, "Hey, here's a good idea," you know, or, "Here's something that we need patented," then DOE then—is that the procedure—go have its own patent attorneys to apply for the patent?

Mr. **Welber**. Then the question would be do they return that patent ownership to us. They've spent taxpayers' money to provide a patent to a private company, or an individual.

Mr. **Lujan**. DOE?

Mr. **Welber**. DOE.

Mr. **Lujan**. Well, how do you work it now? How does it work if there's an invention or a process or anything that you want patented? What's the procedure that you follow?

Mr. **Welber**. Well, right now we apply to the DOE patent attorneys and their lawyers for the patent, and a waiver must be granted, and that's what takes time, a considerable length of time.

Senator **Domenici**. What's next, that's his question. The waiver isn't a patent.

Mr. **Welber**. It's a right to the patent, to exploit it.

Mr. **Lujan**. No, no, I understand. What I'm saying, you say we don't have the money, we can't spend money to patent. You don't need any money. All you do is type it up and send it to DOE and they get the patent for you; is that correct? And then, once you have the patent, then you say, "Well, can company ABC get a waiver so they can use this?" Is that——

Mr. **Welber**. Well, the fact is that a laboratory like Los Alamos or Livermore or Oak Ridge, they have—a part of their funds is profit, or a fee that they receive for the Government for operating that facility. They can use that fee or the profit for pursuing patent applications for their own purpose, and then get the waiver from the Government to use it.

Mr. **Lujan**. You mean the company then hires the patent attorney to get a patent for DOE, and once DOE gets the patent, paid for by the contractor, the contractor applies to DOE for the waiver; is that——

Mr. **Welber**. That's the way I understand it. There are people in the audience who probably know more than I and maybe we can clarify this for you.

Senator **Domenici**. Did you want to speak?

Dr. **Hecker**. Let me try to address it from the Los Alamos National Laboratory standpoint, at least the best as I understand it.

The financial aspects come in, indeed, in the request for petition for a waiver, and the way it works at Los Alamos, Los Alamos itself can, of course, not get any licensing right because it's not a legal entity unto itself. It can only do so through the University of California. So the University of California will, indeed, request the petition for a waiver, and then there's a question as to whether it would then release the licensing right to some private concern. It's that aspect, where the financial question comes in, is during the process of trying to get the petition and the licensing. In that sense, we are more fortunate than Sandia. The University of California can carry that process——

Mr. LUJAN. The university gets the royalties then?

Dr. HECKER. That's still very much under discussion, that normally the university does get the royalties, but there's a question of the split between the university, the laboratory, and the individual. We are currently negotiating with the University of California as to what that split ought to be.

Mr. LUJAN. It doesn't seem to be very much—and I don't mean to take up so much time. But my understanding is—it's incredible; I think it's probably wrong. But that there's only a million dollars that the DOE has taken in in royalties on all its patents? Is that——

Dr. HECKER. I don't know what that number is.

Mr. LUJAN. Do you know, Herb?

Mr. WELBER. I wouldn't be surprised if it's that small, because very recently, in order to understand the technology transfer process, I visited the Charles Stark Draper Laboratory in Boston, which is a—it's not a GOCO, but it's a laboratory which does an awful lot of work for the Air Force. They have a technology transfer policy and a practice that's been in effect for about 5 years now. And they allow their employees to get exclusive rights to patents. And the royalties from all that process to Charles Stark Draper Laboratories is $35,000. So that royalties have not, so far, been a tremendous source of income for the companies that have tried to exploit.

Mr. LUJAN. Thank you, Mr. Chairman.

Senator DOMENICI. Jeff—Senator Bingaman.

Senator BINGAMAN. Let me just ask Mr. Welber—as I understand your background is with Bell Laboratories. Do you have some ballpark sense of how many patents were filed on an average year or in recent years by Bell Laboratories?

Mr. WELBER. For quite a period of time, Senator Bingaman, prior to divestiture, I know, it was almost an application per day. Over 300 per year.

Senator BINGAMAN. And as I understand it, DOE filed 13 for Sandia last year; is that accurate?

Mr. WELBER. That's the number that—for 1985, that is correct.

Senator BINGAMAN. Is most of the—How do we explain most of that difference? Do we explain most of it because of the nature of your work is so sensitive or classified that it's not proper information to be going for a patent on, or is it the problem of the procedure and the bureaucratic hassle of getting it done?

Mr. WELBER. Well, it's a variety of reasons, Senator Bingaman. One is, first of all, the size of the laboratories. During that period it was four or five times larger than Sandia. Another is the nature of its work. Many of the patents that they apply for are protection for right to use, to allow them to use the ideas and not be prevented from their use by prior other companies, and they are much more sensitive to this than the national laboratories are. So they tend to file more patents for protection purposes than a national laboratory would.

And third, so much of our work is classified, as you say. But by filing a patent, unless it's a classified patent, it would be disclosed. So that there's protection of classified information. Those are some of the reasons, I believe.

Senator **BINGAMAN**. Let me ask, also, Mr. Welber, on the lab policy. I understand there's a difference between Los Alamos Lab policy and Sandia Lab policy with regard to patents in a couple of respects, or with regard to scientific research in a couple of respects. First of all, the ability of people on your staff to consult outside the laboratory, and second, the question of whether or not royalties could be—part of the royalty could be returned to the inventor of the idea or the originator of the patent.

In the case of Los Alamos, as I understand it, there is an ability to consult outside the lab and there is an ability by an inventor to get part of the royalty—I guess it's on a negotigated, case-by-case basis. First of all, if I'm wrong in my understanding of the facts, please correct me, or otherwise maybe you could explain the difference, or whether you think Sandia should move more in the direction that Los Alamos has.

Mr. **WELBER**. At the present time we at Sandia follow AT&T practice, Bell Labs practice, with respect to consulting on the outside. We are examining that policy to determine whether it would be beneficial to us and our employees to liberalize that policy. But right now our policy is we do not permit consulting on the outside on work of our employees. We do not permit that.

Senator **BINGAMAN**. Do you consider that to be an obstacle to this technology transfer that we are trying to find ways to foster here?

Mr. **WELBER**. It could very well be an obstacle, especially where an employee has knowledge that could help a small company to get started or stay in business. And we've got to examine that very carefully, and we are.

Senator **BINGAMAN**. What about the second item, of the possibility of royalties going to the originator of a patent? Is that something again that you have to follow AT&T policy on?

Mr. **WELBER**. We choose to follow. We don't have to. On that visit I mentioned to the Charles Stark Draper Laboratory, we have a model that they have instituted that we are examining to see if it would be beneficial for us to follow that practice.

Senator **BINGAMAN**. So you are also rethinking that issue.

Let me ask Dr. Hecker, if I could. In your testimony you said something about how the University of California could delegate authority to the laboratory to go ahead and essentially, I guess, go for these waivers; is that my understanding of what you said? Could you elaborate on that a little?

Dr. **HECKER**. Certainly. What I said was that we would like the University of California to delegate the authority to either elect or waive title in the name of the university, but to have it done on location at the laboratory rather than centrally at the University of California headquarters in Berkeley.

Senator **Bingaman**. And is that something that is being considered by the University of California? I mean, would this, in your view, substantially increase the ability of the laboratory to get some of these ideas out in the commercial sector and is it something they're considering changing their policy on?

Dr. **Hecker**. I think it would indeed help, because as I have pointed out before, one of the major frustrations is one of time delays. We face that with, in our case, both at the University of California and then working it through the Federal system. And so we would like to decrease that frustration and decrease the time that it takes, and doing it locally, being given that authority from the university, would help greatly.

We are negotiating that with the university at the present time, but at this point that authority has not been delegated.

Senator **Bingaman**. As I understand it, Mr. Welber, it's—the issue does not exist with regard to you because of the limitations in the Bayh-Dole legislation, so the authority does not exist with AT&T to do what the University of California has the authority to do with regard to Los Alamos?

Mr. **Welber**. Yes. We are actually doubly excluded because we are a weapons laboratory and we are operated by a company for profit.

Senator **Bingaman**. Let me just ask either of you a general question that occurs to me. I've been struck in the few years I've been in the Congress by the shift in the research funding to the two national laboratories toward more and more emphasis on weapons research and a reduction in emphasis on energy research and other types of research. I've seen sort of a trend in that direction, I think, which I don't believe is disputed by anybody.

Has that complicated or made more difficult the problem that we're trying to address here, which is trying to get this research out into the commercial sector? I mean, obviously, to the extent that you're not involved—that you're involved in things other than weapons research—the possibility of commercial spinoffs, I would think, would be greater and the bureaucratic obstacles in getting the information out would be less. Am I right or wrong?

Mr. **Welber**. You touch on a very important point, Senator Bingaman, as all your points are.

Senator **Bingaman**. Thank you, but you didn't need to say that.

Senator **Domenici**. It's nice that he did, though. [Laughter.]

Mr. **Welber**. The fact is, though, that with the reduction of research funds for energy, a very important part of our technology transfer is suffering, because one of our most successful efforts have been in aiding in the exploration of oil, in allowing oil companies to be far more efficient in putting wells down, which are extremely important and expensive. And drill bits, we have improved those with the research funds. So that we've helped the energy problem, the energy situation, tremendously by those funds, and that is being reduced and I believe the country will not benefit from that at all.

Senator **Bingaman**. Dr. Hecker, did you have a comment on that?

Dr. HECKER. Yes, I do. Certainly your observation is correct. There has been a shift in the past 6 years, and as a result of that, there is the natural tendency for less of our work to be directly applicable.

Although the situation need not be as bad as it looks on the surface, and that is, much of the defense-sponsored work is in the quite proper for commercialization in the private sector, and that is certainly unclassified but nevertheless defense funded. So what we would need to do—and particularly it's important now because of that shift—is to streamline the process to allow the nonclassified, defense-funded work, to be able to transfer that to the private sector. I think it's possible, but it really needs work.

Senator BINGAMAN. Thank you very much.

Thank you, Mr. Chairman.

Senator DOMENICI. Let me ask this question of both of you.

Is there anything in the current relationship and regulations that inhibit you, as directors of these two labs, from expressing the laboratory's position with reference to patent licensing and the whole area of technology transfer? Are you at liberty, as directors, to express to us as a committee your individual views as to what is right and what is wrong with the current policy, with reference to licensing, taking into consideration that you run the labs? You aren't in private business, so obviously we ought to be asking the private businessmen what's wrong with it also, and hopefully we'll at least ask a couple of them here shortly.

Could you answer that? Are you under any inhibition in the Department of Energy right now, as your bosses, if we ask——

Dr. HECKER. What a loaded question. [Laughter.]

Let me respond in the following way. Certainly, we're free to express our opinions. Certainly, our opinions need to be guided by proper business sense. [Laughter.]

Mr. WELBER. I think—I like that, Sig. [Laughter.]

I think you can observe that essentially I'm fireproof.

Senator DOMENICI. Then let me ask you both—and I don't care if you do it here today or not—but, frankly, it's obvious that we're not going to have any uniform policy with reference to patent rights and licensing, royalties; they're going to be diverse and obviously we're just getting around in the State of New Mexico where our universities, because of some degree of autonomy, are establishing royalty processes for their own professors and investigators who might come up with an invention, in whole or in part. But at least we're close at the university system. Slightly different treatment between Tech and State and UNM, but they know.

I wonder if it would be helpful to us, and if you could do this with your people, if you could provide the committee with information, background information package, that expresses to the best of your ability how we could better capitalize and utilize the technology potential within your labs for the private sector in the United States, thus products for American consumers and competitiveness, taking into consideration your missions, obviously, how we could better do it in your opinion, what the hangups are, whether that has to do with outsiders looking in on you, which you haven't discussed greatly here—when you talk about patents yourself, we haven't talked about patents for others. Outside ought to be able to patent your things, too, without you all doing it, and they ought to be the ones to make the money on it, and we ought to find out how that can be done in a way that helps Americans and not be so worried about who makes the first buck, in my opinion. But if you could do that for us in writing, with some examples of how the process has encumbered you in the past, it would be very helpful.

You can make specific reference to the existing laws, if you would like, and suggestions that you have—and we don't expect you in that to be critical of how long DOE takes or the like. You might just mention in passing that it's generally accepted that something like this ought to take 30 days, with an asterisk at the bottom of the page saying it's been taking 18 months—that's all right. You don't have to express an opinion. But if you do that for us, it would be very helpful.

Mr. WELBER. We can certainly try, Senator Domenici.

Senator DOMENICI. How about you, Sig? Can you do that?

Dr. HECKER. Yes. We'll certainly do that. [See appendix, p. 201.] I would like to make just one quick comment in relation to your comment about patents for outsiders.

Senator DOMENICI. Yes.

Dr. HECKER. And really, in all of my discussions for the waivers and the licensing, I really had them in mind more than the laboratory in mind, because really, from a standpoint of financial gain, there's really very little of any of this in it for the laboratory. And so I was really speaking on behalf of the outsiders.

Senator DOMENICI. In your comments—obviously, we haven't even scratched the surface on what happens to a patent that is granted in one of these various processes, expeditious or cumbersome, what happens to the outside world that wants to make money on it in that licensing process? We've got to know something about that. Something's wrong when patents stay there. We tend to—in such large numbers. We tend to forget that the patent law of the United States, while it's an ancient mariner, clearly is based upon somebody making money. That's why you do it. And you have a preferred right for a given amount of time.

I understand, and we all do, that the fruits of public money, which you are—whatever comes out of yours is public money—that it ought to have a little different treatment than IBM's money as far as the patent. But somewhere there has to be a better balance than exists now if we're going to get them to draw on it and use it. There is no model, we understand. Nobody has a perfect model. We're exploring one here. You know about it, Riotech. It's a foundation that's going to try to explore better use.

I just want to take one last question and get off the hypothetical with you, Dr. Hecker, and I guess just vent another concern.

Your scientists have developed a scanning process called magnetoencephalography. Some people can't say it, I can't, and so we've said "advanced brain evaluation machine."

Now, as I understand something like that, which clearly very few would have expected to come out of a Los Alamos scientific laboratory, is in an infancy in terms of its development. As I understand that, they went to the New Mexico medical school, which in turn runs the Veterans' Hospital medically, and they started talking about experimenting with this machine. Do I have it right so far?

Dr. **Hecker**. That's correct.

Senator **Domenici**. Now, since this hospital here is run by the Veterans' Administration, the threesome—Los Alamos as scientists, New Mexico Medical School, and the veteran administrators locally—thought it might be a very good local housing right here for its evolution, as part of a major medical center run by the university and VA.

As I understand it, collectively we have asked the VA nationally, since they do a lot of research, to let us take the next step by funding, in a normal research, medical research manner, the further steps in the implementation and research of this machine to see its potential and to improve it for it is in its infancy. I have it right thus far, do I not?

Dr. **Hecker**. That's correct.

Senator **Domenici**. Now, what really bothers me is what are we doing wrong, or what should we be doing, so that that happens, instead of another round of evaluation by somebody—the National Academy of Science or the Veterans says we want to look at it for 12 more months. Do you have any thoughts on that? It seems to me that we, as researchers, ought to marry up our capabilities, even where there is risk. I mean, if we have the final product, we should allow Johnson & Johnson or somebody to take the machine and manufacture it.

But do you have any thoughts on that? It just seems to me to be—that there's something missing in that equation.

Dr. **Hecker**. Let me try to address that.

I really don't have the answer because we don't have much experience in dealing with the Veterans' Administration. But certainly we have experience in dealing with other branches of the Government, and particularly in this area—and let's just call it MEG for short. We do, by the way, really appreciate your interest in this research project because it does have enormous potential.

In our dealings with other Government agencies, and particularly with the Department of Defense, we have received funding from the Army, for instance, to continue to do research on MEG for potential applications with the Army. And, indeed, that's very helpful at the present time, to further the development of both the techniques and the understanding as to what these magnetic brain waves essentially tell us about the functioning of the brain.

However, we've not been able to achieve the same sort of collaboration with the Veterans' Administration, and that's what's needed. I think it would be certainly possible for them to directly fund some of the research at Los Alamos for technique development and then to fund us to collaborate jointly with the Veterans' Administration down here in the hospital to use this as a research tool to get a greater understanding of how the brain works. And so we could really combine the work at Los Alamos on technique development and basic understanding and then to actually do research here in Albuquerque.

Senator **Domenici**. Well, I know we've all been involved, and I want to say to Senator Bingaman and Congressman Lujan, I thought it would already be done and I received word today that the VA wants to spend another 12 months on it or send it off to the

National Academy of Science. And so I solicit your help between us——

Mr. **Lujan**. You have later word than we do. We thought it would be in the end of September——

Senator **Domenici**. That it would be done, yeah. So what I think, we ought to just find a way to get somebody in the Government to spend a little money on completing this research.

Manny, in your absence, I asked if they would, for the record, to the extent that they can, and consistent with their mission, if they would outline in some detail for us the whole process and tell us, to the best of their ability, where the hangups are, how the process could be enhanced, what's wrong with it, where there should be some policy changes. Clearly, they run the labs, but this is an area of extreme expertise and I believe they'll get with their people. Could we have that for the record of this hearing in about 2 weeks? Could you get that ready?

Dr. **Hecker**. That sounds fine.

Senator **Domenici**. We would greatly appreciate it.

Did you have any further questions?

Mr. **Lujan**. No. Let me just apologize for having to leave. I had some telephone calls that I——

Senator **Domenici**. No problem.

We are going to finish the next panel, even if we stay over. We have some private sector people and some institutions that are not Government-owned on the next panel. We want to extend our thanks to both of you. Now, if the next panel will come up here, we'll get started.

I think the staff of the House Committee clarified with you that that question that I asked about licensing information, that if you can—and I would appreciate your telling me now whether you can—if you would get that on the defense part, too, not just the basic science and research of the Department of Energy, in that overall question—can you include that in your information to the committee?

Dr. **Decker**. Yes, sir, I will supply that information with the information you requested earlier.

Senator **Domenici**. All right. Thank you very much.

Senator **Domenici**. All right. We welcome the four witnesses on our third panel. Dr. Jack McConnell, a medical doctor, corporate director of advance technology for Johnson & Johnson; Dr. John McTague, executive director of research for Ford Motor Co.; Mr. Don Silva, Science & Engineering Associates, Inc., and a member of the legislature, an active New Mexican in technology transfer; and Dr. Ray Radosevich, dean of the Anderson Schools of Management. We welcome all of you.

Let's go in the order that we had you listed. Dr. McConnell, do you want to proceed first?

STATEMENTS OF JACK B. McCONNELL, M.D., CORPORATE DIRECTOR, ADVANCED TECHNOLOGY, JOHNSON & JOHNSON; JOHN P. McTAGUE, VICE PRESIDENT—RESEARCH, FORD MOTOR CO.; DON SILVA, SCIENCE & ENGINEERING ASSOCIATES, INC.; AND RAYMOND RADOSEVICH, DEAN AND PROFESSOR OF MANAGEMENT, ROBERT O. ANDERSON SCHOOLS OF MANAGEMENT, UNIVERSITY OF NEW MEXICO

Dr. **McConnell.** I do, Mr. Chairman.

With your concurrence, I'll speak from down here.

Senator **Domenici.** All right.

Dr. **McConnell.** I am pleased to be here to discuss a subject of mutual interest, the commercialization of the Federal labs technology.

I am fascinated by the discussion this morning. This is my first experience with a congressional hearing, and I'm fascinated in how we might have an opportunity to bring some of that technology out to assist and aid the health care field.

My experience and practice goes back a few decades.

I can remember when even an EKG was an important new bit of technology. That became important to me when one of my first patients came in in the midst of a heart attack. I was just a new graduate and out in practice. I tried the best I could to take care of him, and I said, "I don't have an EKG, but I'd like to take you over to the hospital where there is one and we'll do an EKG on you there." He says, "No, I've got to go to another meeting. As soon as you finish here, I'll take off."

My nurse, who had been in practice some 30 years, said "I don't think you ought to go. You ought to stay here until you're feeling better." But nothing would have it. He walked out—he was going to go. As he walked out the door, he had another seizure and collapsed. For all intents and purposes, he was dead by the time he hit the floor.

I said, sort of half out loud and half to myself, "Great Scott, what do I do now?" My nurse said, "Well, now, the first thing you do is turn him around so it looks like he's just coming in." [Laughter.]

What I might prefer to say, sir, is commercializing Federal lab technology is optimized in some of our national assets, because they truly are national assets. They are the makings, they are the beginnings, of an enormous number of products that I think can be developed to benefit our society.

I'm going to ricochet through some of these slides, Senator, for the sake of time here and get to the points that I would most like to make.

First, why commercialize? Well, first I would like to provide a competitive edge for U.S. corporations. U.S. companies, at least those that compete in the international arena, are required to do so—are required to raise sufficient funds to fund their own research, and they compete head on with companies whose research is paid for by their governments. This is true in a number of countries, especially so with the Japanese companies. In fact, they have raised it to such a fine art that one begins to wonder if it may be a national policy that they have.

It's not just a problem with the Japanese. It's a problem also with companies from Great Britain, Italy, Germany, and France. But if we had access and more ready, more easy access to some of the technology that is in our national labs, I think it would go a long way toward equipping the U.S. companies to compete on an equal basis with some of the foreign competition that we encounter. And when you consider the trade imbalance process, the implications for achieving this are profound.

The second point is to eliminate duplicative research activities. As I said, we must fund our own research and chances are that some of the research that we fund has already been funded and completed by our Federal labs. This imposes a double taxation on our citizens. The double payment, first of all, comes in—we pay taxes, which go to the national lab to fund their work, and then we pay again when the product costs are increased as a result of our having to pay for the research again.

The third point, it would shorten the development time. To do duplicative research costs private industry time, and that adds needlessly to the cost of the development and it allows competition to catch up on a competitive strategy and use your—and forces you to use your resources probably in an unwise fashion.

Next, it would bring research of the highest quality to private industry. It's good to remember that high quality research equals high quality products. It's almost never true that you can start out with mediocre quality research and end up with a product that ever reaches its full potential.

I was visiting with Pete Miller, Dr. Miller, at Los Alamos recently, and he and I were talking about the quality of the personnel and the quality of the research. It occurred to both of us that one follows the other, that they have captured some of the brightest minds and in so doing their work reflects that brilliance.

Next is to deliver advanced technology to private industry for new product development. The technology already exists. I'm not talking about work that needs to be done. It already exists. That could be the basis for an emormous number of new products, certainly in the health care field. And if they were delivered on a timely basis, and at a reasonable cost, private industry could translate those into prototypes and to products for the benefit of the whole of society.

The sixth reason, create new jobs. The work that goes into translating the technology, further development, research, manufacturing, advertising, production, and so forth, and finally the marketing, I think is the genesis for thousands, probably tens of thousands, of new jobs.

So, in summary, provide a competitive edge, eliminate duplicate research activities, shorten the development time, bring research of the highest quality to private industry, deliver advanced technology to private industry for new product development, and create new jobs.

Now, the two points I want you to think about when you're structuring this legislation, I use the term "must"—it may be a little strong, but I feel strongly about it. Technology should, where possible, be made available on an exclusive basis. Experience has shown us over the last 30 years that the public benefits very little when the technology is made available on a nonexclusive basis. If everyone owns it, no one owns it. And if everyone has responsibility for it, no one has responsibility for it.

There are very few companies that can afford to spend the enormous sums of money that are necessary that will bring the product to the market and then find that a small company that did not do that can spend a fraction of that sum and take that market away from you. We need to have that assurance that the tens of millions of dollars that will be spent to bring the product to market, we will have some proprietary rights to it so that we can afford to spend those sums.

Second, U.S. companies should have right of first refusal. I urge us to construction legislation to make sure that that's the case. I have no desire to see technology paid for by the citizens of the United States transferred overseas until we're absolutely certain that there is no company in the United States that has an interest in it.

By the same token, I don't think we should bury technology. In fact, on a philosophical basis, I don't even think we own it. We hold it in custody for a while. And if I could refer you back to one of the earlier slides, I hope we will find ways to optimize that.

Fred, if you would turn off the slide projector there, I'm going to speak just ad hoc for just a bit.

Los Alamos has developed a laser, an excellent laser. I'm not sure what the original purpose of it was, but private industry has found—more particularly, the health care field—has found an application for it that will allow us to take that laser and in 15 seconds reshape and reconfigure the eyeball. No matter whether you are near-sighted or far-sighted, or have an astigmatism, we can reshape that eyeball so that it's optically correct.

Now, the savings and inconvenience to those of us that wear glasses would be enormous. But over beyond that, the savings to the health care field would be magnified enormously. If we want to bring down the cost of the health care system, this is one way to do it, the introduction of technology which already exists in our national labs to the private industry.

Sandia has already brought some technology to the health care field in the form of an insulin pump. I dare say, there are other opportunities there. I'm not quite sure how best to get them out, though, and that's part of the question.

We have made great strides over the last 30 years in the health care field. We have brought under control some of the great scourges of the world—tuberculosis, syphilis, pneumonia—and the diseases that are left are truly the great unanswered questions of medicine, and the answers to them are not easy to come by.

The three great causes of death in our society are the cardiovascular diseases, stroke, and cancer. Quite frankly, disease doesn't care how we structure ourselves, whether you are a Federal lab, private industry, or academia, or whether you are a physician, an engineer, a physicist, or a biologist. We seem to be hung up a great deal on whether we belong to one or another group or have a certain formal degree, at the same time that disease is moving through society and wiping out us in ways that need not be. What is necessary is a multidiscipline approach, bringing together the technologies that already exist in the labs, or can be created there, making them easy and accessible to private industry, moving them through in a greenhouse effort, probably through our universities, and from there to private industry, to the patients.

If we can do that on a timely basis, and at a reasonable cost, I have no doubt that we could affect very greatly some of the great causes, some of the great diseases of the world that are still left to be answered.

Thank you, Mr. Chairman.

[The prepared statement of Dr. McConnell follows:]

Testimony - September 4, 1986

Mr. Chairman, Members of the Press, Ladies & Gentlemen:

Thank you for the opportunity to share a few moments with you to discuss a subject of mutual interest -- the Federal Labs. Some have titled the activity we are involved in here as "The Transfer of Technology from the Federal Labs to Industry". I prefer to call it "Optimizing our National Assets". The Federal Labs are truly a national treasure. They were started in the early forties and have grown from a small beginning of a few hundred people to 65,000 employees with an annual operating budget of $3.5 billion.

It appears from my vantage point that they have faithfully discharged their responsibility to the charter. The Federal Labs have attracted some of the brightest minds in our society, supported them with the latest equipment, facilities and access to data. They have developed a marvelous environment for inventiveness and creativity. I haven't come to criticize the labs. Rather, I am here today to praise them and to see how we can create background information leading to legislation which will assist in optimizing the technology developed in our labs.

I believe we can all agree that a portion of the science and technology in our Federal Labs is now and must continue to be classified. I expect mechanisms are in place to determine which portion can be declassified and made available to universities and private industry. I have no doubt that within that unclassified portion there are opportunities that will yield enormous benefits to our society.

There are numerous reasons why the Federal Labs should declassify and assist in making that technology available to private industry and universities in the U.S.

First: U.S. corporations, for the most part, must generate sufficient funds to finance their own research and development. Those corporations which do business in the international arena find themselves competing head on with foreign corporations whose research is often paid for by their governments. In Japan, this policy has given Japanese businesses a considerable competitive advantage. Companies in other foreign nations such as Great Britain, West Germany, France and Italy also benefit from close government-industry ties. If technology that is already in the labs could be made available to private industry in this country, it would go a long way toward equipping U.S. corporations to compete on an equal basis with the foreign competition. When considering our own trade balance crisis and other U.S. economic issues affected by international business, the implications of achieving this kind of balance are profound.

Second: U.S. companies, under present circumstances, must fund research activities which, in many cases, have already been funded and completed by our Federal Labs. In effect, this is imposing a double payment on our citizens. In the first instance, they pay taxes to support Federal Labs research and then they pay again when product costs are increased to offset the expenses of duplicative R&D.

Third: Duplicating research costs private industry time. This extension of the development period --

. Adds needlessly to the cost of a product.

. Allows the competition to catch up with a competitive strategy and use resources which could have been applied more wisely during the development process.

Fourth: The quality of work in the Federal Labs often exceeds that which is possible in private industry. It is good to remember that a product is never better than the research on which it is based. If one starts a project with research of the highest quality, than one has a better chance of producing a product of the highest quality. On a visit to Los Alamos, I mentioned to "Pete" Miller, Deputy Director, Energy, Research & Technology, how impressed I was with the quality of the personnel and their research. We agreed that one follows the other. As I said earlier, the Federal Labs have captured some of the brightest minds in our society. The quality of research reflects that brilliance.

Fifth: Technology exists in our Federal Labs that is not readily available to private industry. This technology provides the basis for creating entirely new products for our society. If the Federal Labs could deliver the technology on a timely basis and at a reasonable expense, I am confident that private industry could translate that technology into products.

Sixth: Translating technology into products could result in creation of new jobs. The work involved in research, development, manufacturing and marketing of these new products could be a source of thousands, even tens of thousands, of new private sector jobs in the U.S.A.

In summary, if we enact legislation which allows private industry to assist our Federal Labs in optimizing our national assets, we could --

- Provide a competitive edge for U.S. corporations which compete in the international arena.
- Eliminate duplicative research activities and funding.
- Shorten the development time to translate ideas into products and become more competitive in the marketplace.
- Bring research of the highest quality to private industry.
- Make available new product opportunities that do not now exist.
- Create new jobs.

There are two key elements I think we need to consider as part of any legislation in this area.

First, technology must be made available on an exclusive basis. Experience over the past 30 years has shown how little government research benefits the public when it is made available on a non-exclusive basis. Very few companies can afford to invest money to finish development work, obtain clearance by the Federal Regulatory Agencies, and spend the enormous sums of money on marketing only to have a competing firm take the market away by waiting until the development phase has been completed and paid for by some other business.

Second, I urge us to construct legislation that will make certain that the U.S. companies have the right of first refusal on the technology in our Federal Labs. I have no desire to see the technology which resides in our Federal Labs and paid for by the taxes of our citizens transferred overseas until we are certain that no U.S. companies have an interest in the technology. By the same token, I do not believe we should bury technology. I don't think that we, meaning the Federal Labs, or anyone else owns technology. We hold it in custody and I couldn't condone burying it forever. I would prefer to see it used by someone if we are confident that a U.S. company is not willing to take advantage of it.

I have been speaking of the benefit of the Federal Labs to private industry. Let me suggest that there are benefits going in the other direction. I suspect many of the employees in the Federal Labs would very much like to see their ideas and concepts completed and translated into products which would be advantageous to the public. There must be a certain feeling of incompleteness when ideas are left unfinished. Given the caliber of employees at the Labs, they must get a new sense of worth when they see the positive impact that their science and technology has on society.

Closer links between the Labs and private industry will broaden employee contacts which, in turn, will add an extra dimension of intellectual stimulation. Situated as the Labs are in a relatively closed environment, employees are shielded from some of the brighter minds in industry whose mindset regarding research and development issues and opportunities could challenge new investigation, projects and achievements.

Another benefit is an extended and expanded involvement with our universities. This cross-fertilization of ideas and personnel with the academic environment could yield significant results. I am certain that scientists in our universities would benefit and I expect that the scientists in our Federal Labs may as well.

The effort needed to create wise legislation to aid in optimizing the opportunities in our Federal Labs will definitely be worthwhile. Technology exists now in the Labs to assist the health care field with some of its major problems. For instance, using the technology of Excimer lasers developed at Los Alamos, it is possible to reshape the cornea of a patient in 15 seconds -- a procedure that could eliminate the need for the patient to wear contact lenses or glasses. The reduction in cost to the health care field could be enormous, to say nothing about the convenience to the patient.

Already technology developed at Sandia Labs has been translated into an insulin pump which reduces the need for the patient to use insulin on a daily basis. It may be possible to develop a membrane based on technology at Los Alamos to create an artificial pancreas which could eliminate entirely the injection of insulin or the need for checking on the level of sugar in the blood or urine.

We have made great strides over the past 20 years in the field of medicine. We have brought under control many of the major diseases -- tuberculosis, pneumonia, syphilis, etc. The diseases that are left are truly the great unanswered questions of medicine and answers to them are not easily come by. I am not at all sure that the science and technology of the health care field are adequate to attack these diseases -- at least on a timely basis. It will require a better coordination of resources of many groups to achieve the final solution. Diseases don't take into account how we structure ourselves in academia or research labs. We will need a multi-discipline approach to solve some of these problems. I believe that technology already exists in the Federal Labs which will give us a boost in this direction. If we can structure legislation which will allow us to optimize the research of the Labs, we can more effectively leverage that research throughout our society -- yielding benefits to our universities, private industry and ultimately the citizens of the U.S.

Senator DOMENICI. Thank you very much, Doctor.

Let me say for those who don't know, Dr. McConnell is, as I indicated, the corporate director of advanced technology for Johnson & Johnson. It is not an accident that he is here. Johnson & Johnson joined the Riotech Foundation and contributed $50,000. Dr. McConnell is on the Board of Directors of the Riotech Foundation. As a result, for about 2 years he has been in and out of Albuquerque, as that new institution struggles with the idea of whether it could be one of the facilitators of the technology transfer in the broadest sense—as a matter of fact, in the very sense that he has described, where it does not limit its approach to patents and licenses but also how do you get the mix of the private sector with the universities, with the labs, that focus on certain capabilities that can be enhanced. So this analysis that he has made here, while it is obviously predicated upon his overall concern in the health field, has been to some extent tailored by what he has learned about the labs.

I think it's fair to say, Dr. McConnell, that you remain almost overwhelmed by the amount of knowledge and expertise that is within the labs and continue to wonder when we will use it. Is that a fair statement?

Dr. MCCONNELL. Correct.

Senator DOMENICI. Thank you very much for your testimony.

Dr. John McTague, executive director of research for Ford Motor Co. We welcome you.

Dr. MCTAGUE. Thank you, Senator. It's a pleasure to be here today, and I want to commend both you, Senator, and Senator Bingaman and Congressman Lujan, for your attendance here today and for this hearing, but even more so from my 2½ years of experience in the White House, including being the President's science advisor, I'm aware of the strong interest all three of you have had. And I greatly appreciated the close interaction I had with your staffs on these very important issues that we're addressing here today.

I have a statement for the record that I do not propose to read, if it's permissible with you, but I would just like to summarize a few——

Senator DOMENICI. It will be made a part of the record.

Dr. MCTAGUE. Thank you.

This country has tremendous resources in the research area. We do about half of all of the research and development in the world, and half of that is funded by the Federal Government. We are facing an unprecedented challenge in the areas of international economic competitiveness, but I don't think that that should cause us to lose our nerve with respect to the resources that we actually have in the R&D area and the importance of these resources, as has been documented by the President's Commission on Industrial Competitiveness as well as other fora.

What we are properly focusing on today is how to best utilize these resources to get multiple payoff. There's no question in my mind that the national laboratories and the Federal laboratories as a whole are a tremendous resource for carrying out missions that are appropriate for the Government; that is to say, national security, health, space, et cetera. These resources can and must be better utilized to the good of the Nation as a whole, however.

It seems to me that we have made a lot of progress in recent years in this direction—and I'm not saying this just because I have invested some of my own time in this in the administration. But I believe that the foreign challenge has caused us to focus on how to better utilize these resources and many actions have been taken by the administration, and in particular by Congress, along these lines. That is to say, several mechanisms have been set up to improve the situation. We've been discussing patents earlier this morning.

The Stevenson-Wydler Act, which was enacted several years ago, was one of the earlier concrete measures. This set up several mechanisms for technology transfer, one of which was setting up the Offices of Research and Technology Applications in Federal Laboratories. And it also set up technology centers which the administration never implemented, which was the first question I was asked in my confirmation hearings, by the way, by Senator Gorton—why were we opposed to that.

Well, I never favored these mechanisms when I was in the administration, and I don't favor them now. I think they address the wrong issue. I do favor their impact, however. As in the story with the man with the mule, he gets off and takes the 2 by 4 and smacks the mule in the nose, and his fellow passenger said "Why did you do that?" He says, "First, you've got to get their attention."

I think the Stevenson-Wydler Act and several other congressional actions have got the attention of the ponderous Federal bureaucracy to move in the right direction. I don't think the mechanisms do the job. I think they do change the tone.

The most important issues to note in my opinion are that technology transfer is a human activity; it's not buying and selling patents or buying and selling instruments that are put on a shelf so much. It's getting human beings who have knowhow in their heads to communicate it to others in a two-way manner. We have a lot of entrepreneurs out there, a lot of businesses out there, whose interactions with Government and national laboratory scientists could be made considerably more fruitful to the benefit of both.

It's not so much—Senator, earlier you remarked on balancing national security concerns with technology transfer. I don't think it is so much a one versus the other, and it's important for us to get to the frame of mind where both can gain by increased communication.

It was mentioned earlier by Dr. Decker that there is no one solution to the problem of increasing the efficiency of technology transfer. I certainly agree to that. And, Senator Domenici, you emphasized two particular concepts, namely, risk taking and initiatives. I think it's incumbent on policy makers to create and encourage an environment where local individuals will take risk and have incentives to take risk. We don't legislate creativity in science from a central level in Government. I don't believe either we should legislate from a central level in Government how best to implement technology transfer. I think what should be done from the Federal level is to set the tone, saying this is not only an acceptable mission, it is a necessary mission, and we will back you up as you try several classes of experiments. Not every means will work.

As you pointed out, Senator Domenici, we may make a mistake, for example, in the national security area by opening things up too much, but it's clear right now we are at the opposite extreme. And I would like to see us get to the point where we have to step back because we have been too bold.

In any event, I think we do have the mechanisms in place in terms of the people. If we give those people incentives to run with the issue and say, even if you make mistakes, we're going to back you up, I think the resources that this country has will stand us in good stead over the coming decades.

Thank you.

[The prepared statement of Dr. McTague follows:]

Testimony of Dr. John P. McTague
Vice President - Research
Ford Motor Company

Joint Hearing of
the Senate Subcommittee on Energy Research and Development
and the House Committee on Science and Technology
"Commercializing National Laboratory Technologies"
Albuquerque, New Mexico
September 4, 1986

"Technology: The Human Factor"

Thank you for the invitation to talk with you today. I commend you on your interest in promoting more efficient means of commercializing technologies from our national laboratories. As I have served in academia, the U.S. government and now the private sector, I hope I can offer you a broad-based perspective on this issue as you begin your consideration of it.

As you know, the United States emerged from World War II with a commanding lead in science and technology that rapidly translated into American industrial pre-eminence in most areas of business. In recent years, that pre-eminence has diminished considerably in such industries as steel, automobiles, consumer electronics and machine tools. This erosion has taken place even though the U.S. continues to fund about half the world's R&D and is in the forefront of scientific research in almost every area of commercial interest.

This substantial U.S. investment in R&D is creating a pool of fundamental knowledge many times greater than that being generated by any other nation. It is the potential fountainhead for all manner of new products and processes that U.S. firms could develop in future years. Yet the United States is not translating this strong base of fundamental knowledge as efficiently as it could into commercial ventures.

This is especially relevant with regard to technology developed in the national laboratories. The national labs are tremendous scientific and intellectual resources. Together, the 700 some federal labs employ nearly 185,000 of the nation's scientists and engineers and account for roughly $18 billion per year -- a third of all federal R&D funding, and oine sixth of the Nation's total R&D. That is such a vast resource that we must make every effort to make certain that the nation as a whole, not just the government, gets a good return on this investment.

The fact is that much of what takes place in the national labs never sees the light of day. Part of that is to be expected, since long range research often involves shifts of direction as more is learned. However, inventions of potential commercial importance too often languish on the shelf. Indeed, only about 4% of all 28,000 government patents have ever been licensed -- and half of those licenses were non-exclusive. Now, most of the work done in the national laboratories is at such a fundamental stage that even well-developed ideas will need an extensive amount of refinement before they can be commercialized. And no company is going to undertake that investment if it knows one of its competitors can incorporate the same ideas into its own products and market them as its own. The result should be obvious. Nothing is done, and years of scientific and engineering work that could benefit our competitive position or our quality of life often, in that sense, are wasted.

You will be spending the bulk of this hearing talking about the specifics of this problem and the possible solutions, so I won't dwell on those here. But let me suggest that the underlying cause of these difficulties is a rather simple one: in trying to formulate technology policy, the government frequently does not know what it is dealing with. To most officials in government, and probably to most of the public as well, technology is a "thing," like hardware or a blueprint. It is something one can physically localize, put on a shelf, buy and sell, put a lock on to protect it, and put it to use just by taking it off the shelf.

This is most people's concept of what technology is. But -- and I cannot say this strongly enough -- it is a wrong concept. Technology is not a "thing". Not even the dictionary defines it that way. Rather, according to the dictionary, technology is -- quote -- the application of science, especially to industrial or commercial objectives. And science, of course, is knowledge of the world. Thus, technology is nothing more than the application of knowledge to objectives. And that application can be undertaken only by human beings.

The point is, technology is a profoundly and inherently human endeavor -- not a "thing" at all. All of the so-called high-tech hardware in the world is of no use unless someone -- a human being -- is around to devise ways to apply that hardware to constructive purposes. But mere application is not all there is to it. The human aspect of technology goes much deeper.

First, a given piece of hardware does not necessarily have an obvious or intrinsic set of uses. The applications aren't inherent to the technology. For instance, who could have foreseen that lasers developed originally for military missions, would become one of the most valuable operating room tools? Or that common, everyday glass could be molded to transmit half a million telephone conversations at one time? Often, the most important use to which a piece of hardware is eventually put is the least apparent when that hardware is conceived, meaning that the greatest technological leverage can come not from the development of a device in itself, but from what happens after it is developed -- the creativity of its application.

Of course, a piece of hardware in a given state may not be equally well suited to all applications. For example, the same laser that could kill a ballistic missile could hardly be used to perform delicate eye surgery -- but a laser of a different kind and intensity could be. Nor could an ordinary piece of glass be used to transmit voices, but a hair-thin, purified strand of glass could be. The ability to recognize how an existing piece of hardware could be beneficially modified often can lead to previously unimagined, and enormously useful, applications.

Finally, and probably most important, is the creation of the hardware in the first place. In terms of content, high-tech hardware is about 1% silicon, 1% plastic, 1% metal -- and 97% ideas. For instance, it was the idea of using silicon chips to replace vacuum tubes and wires that led to the modern-day computer revolution; without that idea, no combination of tubes and wires could have ever produced a computer capable of switching 100 million phone calls, or one compact enough to sit on a desktop. And without the idea of stimulating photon emissions in series, no light ray could have been made strong and focused enough to serve the functions of a laser. It was the idea, the innovative concept, that started these technological balls rolling in the first place.

And so we have creative application, creative modification and creative concept. These are the three most fundamental attributes of technology, none of which inheres in the nature of the hardware itself. What is common to these attributes is that they all depend critically on human ingenuity and inventiveness. It is the origination, often out of thin air, of human ideas that drives the concepts, the structures and the applications that lead to what we commonly view as higher technology. Creating technology, then, is the process of creating ideas. And thus, enhancing technology, at its core, is a matter of increasing the efficiency and productiveness of creative scientific thinking.

How do we do that? Drawing from my own experience, I have found that one factor overwhelms all others in promoting creativity. That factor is the free flow of ideas. This is especially the case in science and engineering, where so much new knowledge is generated each year that it is impossible for a research team to keep up with all the developments in their own field, much less in the dozens of related fields. Free exchange, on the other hand, vastly expands the pool of knowledge and ideas available to these men and women. That, in turn, increases the efficiency and productivity of their generation of new ideas. And that, of course, leads to a broadened technology base.

In other words, according to this more realistic view, the ideas of scientists and engineers are the real technology, whereas the gadgets or "things" that we commonly view as technology are, in fact, only the products of technology. Unfortunately, this is not the way the government tends to view the situation. Until recently, government has regarded essentially all technology as things, and it still does so in many cases. One of the most serious results of this viewpoint, as I indicated, is that government has greatly restricted the flow of technology -- of ideas -- from its own laboratories into the commercial sector. In some cases, of course, the national laboratories generate specific blueprints and hardware, much of it for military purposes, much of it legitimately classified, and we shouldn't be attempting to disseminate that. But most of what the labs produce are knowledge and ideas -- technology in the true sense.

Now, if the government sold rights to a device or thing to a private company, even if the device weren't classified, it is true the government would be losing something. But if the government sold knowledge or an idea, it would not be losing anything. The laboratory still would possess that knowledge -- and yet so would a private firm. Given the protection of its investment through exclusive licensing, the private company should have the incentive to develop the idea into a commercial product -- an undertaking beyond both the purposes and capacities of the national labs.

Thus, society would gain while the government would lose nothing. In fact, the government should gain as well, since the uses to which the company put the knowledge and ideas should feed back into the government's research efforts, expanding the pool of ideas available to the national lab scientists. Their work, in turn, should be enhanced.

Recently, the government has moved to correct some of these misguided practices that have inhibited the flow of technology in the past. The Bayh-Dole Act of 1980 and the 1984 follow-up bill, also authored by Senator Dole, have permitted universities and small businesses to retain title to some inventions generated in federally-funded research work. Another bill by Senator Dole, now before the Congress, would be a further step in this direction, allowing, for the first time, large company contractors to retain title to inventions, and providing that royalties from licensed technology no longer flow to the Treasury, but be retained by each laboratory to bolster its research efforts. And the President's National Security Decision Directive number 189 provides that unless the results of federally supported fundamental research are classified, the government cannot restrict the communication or conduct of that research.

Still, despite these advances, there remains a government sentiment against viewing technology as ideas and not as things that still must be overcome. In too many cases, the government continues to view technology as a "thing" to be protected, hidden away, and put in cold storage, when it should be looking instead at what steps it can take to help the it should be looking instead at what steps it can take to help the nation's overall welfare.

In my view, it is critically important that we create means, and even more significant, a climate, whereby individuals are given incentive to explore multiple payoff from the fruits of their creativity, be the payoff for government programs or in the commercial arena. The federal laboratories are effective and even vital contributors to governmental roles such as national security, energy, and health. They are also playing an increased role in enhancing our economic competitiveness through increased communications with the private sector and, where appropriate, joint research programs.

If we encourage the people in these laboratories to continually explore new means of technology transfer, especially through personal communication with local businesses, I am confident that the nation as a whole will get an even better return on its investment.

Thank you, and I welcome your questions.

Senator DOMENICI. Thank you very much.

Dr. Radosevich, dean of the Anderson School of Management, we welcome you, and thanks for your patience.

Dr. RADOSEVICH. Thank you for the opportunity, Mr. Chairman. I would like to depart from my prepared testimony and just comment on a few of the issues raised earlier by previous testimony.

First of all, I would like to say that I believe the Solomon amendment is a mistake, and for a variety of reasons, some of which have not yet been mentioned.

First of all, as described by the labs, there are clearly three areas. There are areas where it is known that it would represent a breach of security, and there are areas where the technology was developed, say, for energy programs, where it's clearly in the best interests of the nation to have it in the private sector.

The grey area is a very large area, and yet I believe that if you decentralize the decision, not from a function in Washington but to those people who are closest to the invention and discovery of the technology, they will best understand the potential applications, because there may be many unforeseen applications in the private sector as well as in the defense sector.

I could give you an example that was cited. The low voltage CO2 laser has had a number of very important applications in the private sector. It may also have some important applications, say, in SDI. But I believe that where the restrictions ought to be placed is on that private company, operating as a contractor under SDI, to keep out of the public knowledge the application, information and technology developed specifically for that application, because I think our primary problem with transferring technology is an inability to envision all of the potential applications that might be made.

I'd like to clearly support what has already been stated as a need to grant the rights to the technology on an exclusive basis. I really agree that the whole patent system has been founded on the basis of establishing an economic worth through a monopolistic position, and that if you weaken that in any way, shape or form, you simply take the incentive to adopt that technology away from a potential adopter.

I believe also that we ought to work diligently to strengthen the technology transfer functions in the laboratories. If you go back to establishing worth with a patent, I think you'll see now that the primary purposes in universities and in laboratories with scientists to develop a patent is to put it on your resume and to have some visibility in the scientific community. You generally do not, nor does the institution, develop a patent with the mind that you are trying to create economic worth through that patent for someone in the private sector. To me, writing a patent and defending a patent is something that requires skills and knowledge and ability way beyond what universities and laboratories have currently built into their technology transfer function, and that's something that we all ought to improve on.

I think there are other things that we ought to do to strengthen this technology transfer function. The assignment of resources I think have been quite inadequate to try to assess the commercial worth. For example, in the granting of licenses, it has taken a great deal of time. Many of those licensing agreements have not been tremendously instrumental in terms of transferring the technology because I believe, again, that most of those people involved in the process do not have the resources for "due diligence" work in terms of determining feasibility in various marketplaces, feasibility of furthering the technology to the point of a producible product, the potential for financing and so on.

The laboratories did cite numerous instances of success in terms of inciting people transfer, and I would like to suggest that we encourage that even further. Again, the exclusivity that we cited is even more critical there because the private individual leaving a laboratory will never be able to secure private sector funding from a venture capitalist with less than exclusive rights to the technology. And so again I think it's important in that dimension.

Finally, I would like to support the thoughts that have been presented which suggest that at this point in time technology transfer really has been an experiment. The results that we have seen to date are minuscule in my mind in comparison to what they can be perhaps a decade from now if we're more innovative in developing new mechanisms and also in treating what we have done so far as an experiment.

There is considerable criticism in the popular press now about the initiatives that have been taken; a few academic studies have been done. Essentially, I think their conclusions are erroneous. I think that we have to recognize that there is an important role for technology transfer. I agree with the Senator's comments, that the real risk to us is not inequities or any misuse of a proprietary nature, but rather the risk that we don't use the technology that is available to us in order to become internationally competitive.

So again, I would encourage you to help us develop new mechanisms, to be more innovative, to encourage the laboratories, to encourage the universities, to experiment on a much broader and a much more creative fashion than they ever have with regard to their potential roles in technology transfer, and to help us build the appropriate mechanisms to monitor those results and determine really whether they are working or not. Right now it's mostly hearsay and anecdotal proof, and I believe we can do a much better job in determining what we can do to advance technology transfer if we do it in a more studied fashion.

Thank you.

[The prepared statement of Dr. Radosevich follows:]

Testimony of

Dr. Raymond Radosevich
Dean and Professor of Management
Robert O. Anderson Schools of Management
University of New Mexico

before the

Senate Subcommittee on
Energy Research and Development

and the

House Committee on
Science and Technology

September 4, 1986

I would like to thank you for this opportunity to suggest several actions which I believe should be taken by the Congress and federal agencies in order to further capitalize on the great national resource embodied in our national laboratories.

My suggestions are to:

1. disregard the vast majority of the criticism directed at past initiatives such as P.L. 96-480 and P.L. 96-517,

2. provide additional incentives and mechanisms for people transfer between labs and industry as the most effective method of moving technology from the labs, and knowledge of needs and the marketplace from industry,

3. expand the incentives and mechanisms that facilitate the use of universities as transfer intermediaries,

4. encourage labs to direct a greater proportion of their technology transfer efforts toward small and local businesses,

5. assist the labs to strengthen their groups which have direct responsibility for technology transfer,

6. promote greater inter-organizational cooperation between national laboratories and industrial firms, and

7. provide the mission and resources to a federal agency such as the National Science Foundation to monitor the effects of new legislation, executive orders, laboratory changes in policy and practice, and other mechanisms to effect technology transfer, as these initiatives are truly critical experiments which must be understood if we are to significantly change the system.

I will elaborate on these suggestions so that they, when combined with other testimony provided today, may suggest specific actions.

1. Disregard criticism of past initiatives.

In the last year, there has been numerous unfounded claims that the changes initiated by P.L. 96-480, P.L. 96-517, the patent reform legislation, etc., have produced unintended and dysfunctional effects. For example, the press has cited instances and future possibilities of scientists who are government employees getting rich by gaining access to technology that they developed while financed by tax dollars. A study reported in the newsletter of the Technology Transfer Society revealed that invention disclosures had decreased in a NASA facility subsequent to the Congressional initiatives. The unfounded inference was that scientists were hiding their inventions so that they might personally commercialize them.

These observers are probably erroneous in their conclusions and hence in their requests for reversal of the initiatives. Most national labs are large and somewhat ponderous organizations in which it is extremely difficult to induce substantial changes in behavior. It is difficult to imagine how the new laws alone could incite scientists to hide inventions, particularly when these initiatives have actually improved their chances of gaining sanctioned access to the technology.

Furthermore, the critic's fears of future consequences are probably unfounded. For example, an expressed concern is that the potential for wealth from the commercialization of one's discoveries might drive the scientists toward applications work thereby ignoring their institution's primary mission of research. However, scientists in universities around the world have had the potential for personal aggrandizement for many decades and yet there has been a very small incidence of personal involvement in commercialization -- unfortunately.

Finally, I would argue, why should we as a nation or as policy-makers worry about who becomes rich as long as the wealth is generated. Why intrinsically should someone who is not the inventor get rich with technology developed with tax dollars while the creator must shun the opportunity? I would argue that the probability of successful commercialization is seriously diminished if the inventor is not included in the process. The critical dimension with which to be concerned is that the technology is used and that jobs, wealth and international trade competitiveness are all enhanced.

2. Promote people transfer.

Most organizations and individuals who are experienced in technology transfer adhere to the premise that the most effective mechanism for transfer is people. Yet many labs discourage the use of this mechanism for fear that they will lose their most creative people. In actuality, the encouragement of people transfer may facilitate laboratory hiring of new talent who will provide a better mix of scientific capabilities for new programs. Laws, regulations and policies that protect slots and reward labs for people/technology transfer may assuage reluctance for the use of this mechanism. I should note that the Los Alamos National Laboratory has been highly successful in the use of people transfer in the last several years. Policies and incentives have encouraged regular departure in order to establish a new enterprise with the inventors' technology.

Patent law and agency policy and practice should encourage people transfer by giving first priority for waiver of government rights or exclusive licenses to the inventors. Current law and executive orders have given federal agencies the flexibility to grant exclusive licenses for the use of federally developed and owned technology. We have encountered regular resistance to do so, and thus, it seems, more definite authority is needed along with greater recognition of the expediency for doing so. I believe the primary barrier to the granting of exclusive rights is a fear of being accused of showing favoritism. However, benefiting everyone with equal access to a technology frequently means that no one is benefited and the technology is not adopted. The patent system itself is based on the recognition of the economic worth of a monopolistic position in a technology. Assurances of intended technology transfer results (such as a guarantee that the technology will be used) for a process of granting exclusive rights to a technology can be provided with three or four year march-in rights. The agreement with inventors which gives them exclusivity should also stipulate that the inventors must remain personally involved in the commercialization process for at least two years before sale or sublicensing of rights.

Since the recognition of a need to which a technology can be applied is a prerequisite to an innovation, we need to determine better methods to combine industrial knowledge of the marketplace with new technologies available in the national labs. The industry/laboratory scientist exchange programs have been used in only a limited fashion and thus there is little evidence to determine their efficacy. Interaction between governmental and industrial scientists at professional meetings and through the scientific literature does result in some transfer, but, in my opinion, there is insufficient incentive for either party to work diligently at effecting significant transfer. Government scientists who are allowed to consult have increased incentives but their motivation is still far below what it might be if they had a personal stake in a commercial opportunity employing their technology. Clearly we need to invent additional methods for synthesizing the technical knowledge in the national labs with the market orientation and knowledge of the private sector. More imaginative programs are needed to create and test new methods, and governmental agencies like the NSF and the Department of Commerce should be charged with seeking new forms of private partnerships in order to develop these programs.

3. Use universities as transfer intermediaries.

Much of the science and technology that is developed in the national laboratories is not ready for commercialization in the sense that more applications work must be done before a specific product or process is available. Although universities are not generally known for the pragmatism or applicability of their work, collaborative arrangements between them, the national labs and industry would have substantial benefits for all three parties. In many ways, national labs can work more readily with universities than directly with industrial concerns. To the extent that a university can become involved with a lab in the evolution of a technology, the university will greatly enhance its resources. I perceive the instance of the Centers for Technical Excellence in the state of New Mexico as a bold experiment of university/laboratory collaboration with strong incentives to involve industry. Many universities are themselves experimenting with methods of technology transfer and commercialization as a means of enhancing their resource base. To the extent that this experimentation is expanded to include a national lab, mutual enhancement and understanding of the technology transfer process will occur.

4. Orient laboratory technology transfer toward small and local businesses.

In most national labs, the preponderance of technology transfer efforts have been directed toward collaboration with large firms. The obvious advantages are the likelihood of substantial technical competence within the recipient institution which clearly facilitates the process and the possibilities of reciprocal knowledge from the large base of technology in sizeable firms. However, there is much evidence that demonstrates the critical contributions made to our economy by small businesses. We all know the statistics verifying that small businesses proportionately generate more jobs, create more capital and exhibit a greater propensity to innovate.

As suggested above, one of the easiest and most effective methods of technology transfer is the transfer of people who wish to leave a lab and carry their technology with them -- either to a large firm or to a start-up or small firm. The priority for small firms that was established in the early technology transfer legislation is not reflected in the results to date. Without people transfer, it is probably more difficult for a lab to collaborate with a small business. Nevertheless, the social benefits for so doing are obvious and the extra effort should be expended.

National laboratories can be a strong stimulus to local economic development. As entities that are not as fully taxed as local industrial firms, they can also represent a burden to public infrastructure. By assisting local small firms, labs can be perceived as responsible members of the local community. At times there seems to be a sense that lab management must strenuously avoid being perceived as favoring local firms in the technology transfer process and that the national obligation implies some form of distribution of lab technology around the nation. A fair access policy without concern for distribution would indeed usually favor a local concern because of the greater ease of access. I personally do not believe that this represents any form of inequity because our experience here in New Mexico is that local firms don't stay local for long. Too frequently the firm attracts investors who wish to move the firm out of state as a condition of investment. Those that do maintain operations in New Mexico frequently have additional operations in other states. Additionally, I would suggest that labs be encouraged to work with local firms because physical proximity greatly facilitates the transfer process.

5. Strengthen laboratory technology transfer functions.

A number of the suggestions presented above have resource implications for the laboratories. My observations are that the groups directly responsible for technology transfer have insufficient personnel and authority to implement any truly ambitious programs. If we are to increase the incidence of successful transfer while creatively experimenting with new mechanisms, the direct effort must be increased substantially.

One change that I would recommend that would require more resources is the assignment of the technology ownership to the lab regardless of whether it is a weapons lab or operated by an industrial GOCO. Under the current system, waiver requests by inventors must go through so many steps that the process frequently takes greater than a year. For a start-up company in particular, this delays investment by an equal period which in most circumstances will abort the effort. If a laboratory technology transfer group were given total responsibility and authority for transferring the rights to a technology, it would require considerably greater capability to assess the commercial potential and choose the appropriate mechanism.

For example, many patents for lab inventions are not now written with the care and perspective of someone who would wish to base a major investment on it and who would anticipate having to defend against infringements. Thus the value and the desirability of a technology can be enhanced considerably, and hence the transfer process facilitated, if the originating institution has full responsibility with commensurate resources.

6. Promote inter-organizational cooperation.

Since the laboratory/industry scientist exchange programs and similar mechanisms have had limited impact on technology transfer, I would suggest the consideration of more innovative schemes. Many other countries, including most European nations, have developed more cooperative structures for performance of research and development activities. For example, government funding of R & D to a user of the technology, rather than directly through a research performing organization, would facilitate cooperation between the technology developer and the user. One could, for instance, set aside a small proportion of an agency's research budget which would be provided to a potential user (as a grant or no-interest loan) to be spent only at one of the laboratories. Such a scheme has been highly successful in Brazil.

7. Create new Technology transfer mechanisms and monitor their effectiveness.

The current technology transfer process has improved considerably in recent years due in large part to some very important and effective legislation. Yet the potential is many times greater than current results. Solutions to many of our pressing national problems lie at least partially in the resource of our national laboratories. To effectively utilize this resource, we will require substantially greater levels of technology transfer while improving the efficiency of the process. To accomplish this, we need better knowledge of the practices of current participants, better judgement of the effectiveness of these practices, additional creative mechanisms to accomplish more transfer, and a system for monitoring and publishing the results. Although federal agencies have been involved in the process for decades, the new initiatives have created an environment within which transfer can flourish if we continue to improve the system in a studied manner.

Thank you for this opportunity to share my views.

Senator DOMENICI. Thank you very much.

Mr. Silva.

Mr. SILVA. Mr. Chairman, first let me apologize for the confusion. I'm sure, as elected officials, you recognize I should be sitting on the right and not the left. [Laughter.]

Senator DOMENICI. That's all right. You're sitting on our right. You may look at it that way.

Mr. SILVA. I do have some prepared testimony, which I think, among other things, reemphasizes the DOD policy on the weapons laboratories and the exclusivity question and their patent policy.

Let me first——

Senator DOMENICI. Would you like that made a part of the record?

Mr. SILVA. Yes, I would.

Senator DOMENICI. Let's do that, without objection.

Mr. SILVA. Let me first ask that, if you do look at the figure that was attached to my testimony, and at the risk of causing a bit of confusion, let me say that we in New Mexico and in the legislature see two ways that the innovation chain produces business creation and jobs, which is what we're interested in. One is for the marketplace, for economic needs, to cause a requirements pull and, therefore, businesses develop something that responds to the marketplace. I think Dr. Hecker called it a technology pull. In fact, we view it as a technology push. The technology can push something into the marketplace that ultimately creates jobs.

What we've done with the Centers of Technical Excellence and the Technology Innovation Program at the State level—because we are rich in technology in the State, thanks very much to the Department of Defense laboratories and to the Department of Energy laboratories—we have created our economic development issues in science and technology around the technology that exists within New Mexico and look forward to technology pushes coming out of the laboratory—laboratories. Therefore, technology transfer is most important.

And so, one point I would like to make from the legislative standpoint, is please tune up the dial, if you will, and the volume on technology transfer coming out of our laboratories. It's important to our approach in New Mexico.

The second thing I would like to say is—and I'm pleased to be on the panel with Johnson & Johnson and Ford Motor, two giants—but, in fact, don't forget the small businessman. Coming from small business, I can tell you—and I think it's been proven in many studies—that small business tends to be better innovators. The larger companies, the Federal laboratories, are excellent sources of technology, but the turning of that technology into a commercialization process really comes out of the small business sector. And that's the other cornerstone of our economic development policy at the State level in New Mexico; it's geared toward small businesses and growing our own businesses. And so anything we can do in that arena to help in the technology transfer process would be most important.

Let me say specifically—and I recognize this defense security question is an important one. But, for example, you shouldn't need a Q-clearance to get into one of the national laboratory's library to look at unclassified matter. Many small businesses can't afford a library as extensive as some of the national labs and right now we're in the situation of needing a clearance just to get in the laboratory to look at unclassified stuff. There are other ways of going through intermediary libraries to get information, but it still is a problem for small businesses.

Another point I would make is there is a lot of manufacturing technology within the national laboratories that relates specifically to the weapons business. I grant you, there's a concern there in the security arena. But I would submit to you that there is a lot of information that could be transferable that is totally unclassified to help us in the manufacturing side, and that is one of the areas we see a need for from the State level, again for small businesses, to help them with manufacturing processes, to create the factories right here. And so I would look to letting the folks, say, at Sandia, decide what information could be made unclassified in the manufacturing arena to help small companies get started.

On the exclusivity issue of patent rights, I think that's absolutely important and I'd like to echo what's been said before. I think we have the fairness issue. Maybe we ought to change the mindset and use a "guts" or enterprise issue; who's got the guts to come to the table first and say "I want to do it, this makes sense," and somebody pass judgment on it and say, "OK, we'll go with you."

Senator DOMENICI. That's pretty hard for the Government to do, you know.

Mr. SILVA. Well, maybe we ought to think about it.

Senator DOMENICI. Fine. There's no doubt in my mind. I'm just saying you've seen it here. Look at the complexity that we've got built into this system. I mean, this is excluded, that's not excluded, this is waived, that isn't waived. Go to California, go all the way to Washington. Then what do you have when you're finished? I mean, it's pretty tough.

Mr. SILVA. A lot of time wasted.

Senator DOMENICI. That's government, though.

Mr. SILVA. I would, as a specific suggestion, suggest that—and it's in my prepared testimony—that as a defense and energy contractor right now, we are allowed a portion of our overhead rate for what is called independent research and development, or bid and proposal effort, in addition to keeping the lights on and the doors open. I would suggest that you have the staff look at the possibility of a policy change which would allow those companies that are contractors to the Department of Defense and the Department of Energy, to have an allowable part of their overhead charge involved in technology transfer activities specifically, not just as part of an overall overhead issue. I think this would provide an incentive to getting the small businesses into the technology transfer process and expanding the process, which as I said is very important to us in New Mexico.

I appreciate the opportunity to testify before, and again remind you, don't forget the small businessman in this overall process of technology transfer.

Thank you.

[The prepared statement of Mr. Silva follows:]

04 September 1986

Honorable Pete V. Domenici
Chairman Senate Subcommittee on Energy
Research and Development

Honorable Don Fuqua
Chairman, House Committee on Science & Technology

Subject: Testimony of Representative Don Silva to the Committees

I am pleased for this opportunity to testify before your respective committees on technology transfer issues. Let me first speak with a Legislative hat on.

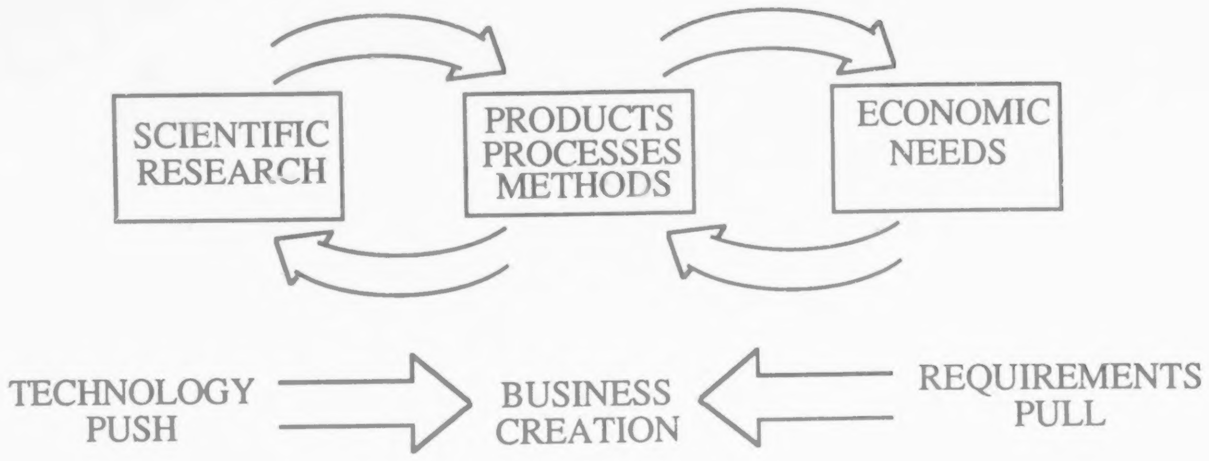
As Co-chairman of the New Mexico Science and Technology Oversight Committee and a former technology transfer agent for two of the major DOD laboratories as well as a writer and sponsor of legislation that is seeking to expand our economic development efforts in New Mexico in Science and Technology; I cannot over emphasize to you the importance of technology transfer to our efforts to expand and diversify our New Mexico business base into the science and technology arena. There are two ways to expand (see figure) industry - one is through a market requirements pull - the other is through a technology push. New technologies will enable the market place to create a demand for a product and enable us to grow businesses. Technology transfer is a key element in that process. I can't exhort you enough to dial up the volume on technology transfer initiatives for all federal facilities and laboratories. I believe you must make it an integral part of their mission and make it as simple as possible for them to conduct technology transfer operations. Our economic development initiatives in New Mexico are strongly based upon expanding our existing small businesses and growing our own small businesses. Technology transfer helps that process.

Now let me speak as a small businessman whose company does a major part of its business with the Department of Energy and Defense or their major subcontractors. I'm sure you are aware that small businesses rather than large ones do the best job of innovating and developing businesses around new technologies. Federal laboratories, however, are a rich source of new technologies. On the other hand, small business cannot afford the overhead to dig this technology out of the federal laborabories. Security clearances, for example can be a big barrier. In addition, DOE has taken a rigid position on licensing and proprietary rights - especially when it involves their weapons laboratories and they do not delegate that function to the technology transfer offices at each laboratory. It is my understanding that their (DOE) approach is to issue no exclusive technology licenses from DOE HQS. This eliminates the incentive for private investment to complete the development process to commercialization. You may want your staff to examine this policy.

As you know the Defense Contract Audit Agency sits as both prosecutor and jury in the determination of allowable overhead charges on government contracts. I understand that large DOE contractors are allowed to allocate to a designated overhead category some, although not all, of the time their staff spends in community or civic activities. This is not true of smaller contractors. They are not being afforded the same opportunities. For example, one of my staff members is advising a consortium of local hospitals on disposal of hazardous wastes. That time he spends providing "technology transfer" support is not allowed as a legitimate overhead item by DCAA. As another example, there are members from private companies who serve gratis on our Science and Technology Commission. Their input as private sector representatives has been invaluable to our economic development initiatives. Their time, however, is not recognized as a legitimate overhead consideration by DCAA for their companies. Yet on the same Commission there are major DOE contractor staff who are allowed to provide their time to the state effort and it is recognized as an allowable overhead item. Thank goodness this is a recognized overhead item for these national laboratory contractors and they are allowed to provide the state with some of their time. My suggestion is that you consider the same opportunity for private companies that are subcontractors of the major laboratories.

My suggestion to the Committee is I believe a simple one. Have your staff examine the potential for allowing not only the DOE/DOD major contractors the opportunity to charge overhead time to technology transfer and community services initiatives but consider opportunities for the DOE/DOD major laboratories to pass through to their contractors allowable overhead charges to devote time to technology transfer activities. In other words, allow small businesses the opportunity to indulge in technology transfer when they are a contractor to a major federal laboratory and provide them an incentive to do this by allowing a recognized amount of overhead effort to technology transfer.

INNOVATION CHAIN


SCIENTIFIC RESEARCH
PRODUCTS PROCESSES METHODS
ECONOMIC NEEDS
TECHNOLOGY PUSH
BUSINESS CREATION
REQUIREMENTS PULL

Senator **Domenici**. Thank you very much.

I think we can stay to our 1 o'clock schedule and each get a chance to inquire. I have just one question.

Mr. **Lujan**. What he's telling us is to hurry up with our questions.

Senator **Domenici**. I'm going to take one, and then I'm going to yield time to you.

Let me ask. You made an interesting statement, Dr. McTague. You said the United States of America spends 50 percent of the world's research and development money, resources. That's a true statement?

Dr. **McTague**. That's true for the non-Communist portion of the world. It's very difficult to evaluate in a realistic manner their R&D, but it's close to true for the world.

Senator **Domenici**. Close to true for the world.

Dr. **McTague**. Yes.

Senator **Domenici**. Any of you, all of you, are we getting 50 percent of the benefit of applied—of research and development money?

Dr. **McConnell**. As regards the subject at hand, the Federal labs, we're not even close to it. Some have suggested that they are about 20 percent efficient at transferring that technology, and when we think of the enormous amount of—the enormous number of patents I think that the Congressman mentioned this morning, and the few that have been moved into private industry, it saddens me that we're wasting a national asset there.

Senator **Domenici**. What do you think, Doctor?

Dr. **McTague**. I certainly agree with that statement, but we should also realize that we are getting other things out of our national laboratories. It's a question of getting multiple payoff. And we can do it. And as you people keep on the pressure, I think we're going to do it.

Senator **Domenici**. What do you think, Ray?

Dr. **Radosevich**. I don't believe we are, and I think the major problem is not within technology or the immediate transfer process, but it's in many of our institutions, primarily related to the dysfunctions of entrepreneurship. We keep people from entrepreneuring as they ought to. That's our international competitive advantage. We entrepreneur better than any other nation, or we used to. I don't believe we are anywhere near to the potential that we should these days, or that we could, and I believe better access to the technology as a basis for entrepreneurship is something that can unlock that potential in this country. But technology is only one of four or five essential ingredients, and until we discover the appropriate mechanisms to use that Federal technology in a private sector entrepreneurial process, we're not going to at all realize even a small portion of the potential.

Senator **Domenici**. Don.

Mr. **Silva**. I would basically agree. I think there is some going on. We just need to do more of it, and I think we need to involve the small businessman.

Senator **Domenici**. Congressman Lujan.

Mr. **Lujan**. Thank you, Mr. Chairman. Just a note on that.

You know, when we passed all of the changes to Bayh-Dole and all of that, we did make a change that allowed small business and nonprofits to keep the fruits of whatever they invented, even under Government contract. So there is——

Let me—as we have sat through the morning—and this is my last crack at it, I guess—I've just been kind of writing down. What are the things that we can do to really get this technology out there? Where's the bottom line and what's the best way to do it? So the things I've come up with, brokers, like Riotech. There's an article here about Rimtech in Business Week of August 11, where they go to JPL and get information and sell it for $25,000 to a company and say, "What do you need; we'll go get the information."

Maybe that's part of the answer. They've got cleared people to go in and read that information in the classified room, even though it may not be classified information. Maybe the university or maybe somebody like that. So one is brokers.

Contractors on the job, employees on the laboratory, reading the literature that is published. Incubators—the National Bureau of Standards has the practice of bringing—of having industry send people in to work on computer security or whatever, and they walk out with the information. You know, we keep trying all kinds of things; we keep fine-tuning Stevenson-Wydler and Bayh-Dole and we're still not very good at moving it out.

Then I wrote down what keeps it from moving out: Lack of interest, interest on the parts of maybe the laboratories or the industry; lack of incentives for the labs or industry; too much classification, not exclusive rights that someone can get.

I would like just basically to see what you all think, which is the best way to get it out. If we take all of these different problems that we have, how do we get it out best? Just the bottom line. Maybe a very simple—maybe too simple a question.

Senator **Domenici**. We'll start on this side and go this way.

Mr. **Silva**. I think you've got to get the decisions out of Washington and into the laboratories. They're closer to the problem; they're closer to the technology; they know what's classified and what's not classified; they can even declassify, for example, certain manufacturing technology or weapon technology, to take a laser system and allow you to use it for air monitoring. So I think you've got to do what they say and in search of excellence, decentralize and get it out into the field and let the laboratories, who have very competent people, make the decisions, instead of keeping it in DOE in Washington, for example, to use one piece of it. And the same thing at the defense laboratories, too.

Senator **Domenici**. Ray.

Dr. **Radosevich**. I would say first we need to remove some of the barriers that we've talked about today, such as the untimely fashion of getting the waiver approved. I think those things are being done.

In a more dramatic sense, I don't think we have at all been creative in discovering all of the institutional incentives that we can develop for our universities and for our laboratories. Just as a single example, let me cite my experience in working with the Brazilian Government. Their values with their scientists are very similar to ours. There is much greater interest in developing more basic research than there is in finding applications and solving some of the national problems. And there was a very powerful effect when the Federal Government, in providing support to those institutions, instead of giving it directly to them, gave it to those people who were in need of the technology—for example, small businesses—with no-interest loans or grants of money in the form of a chit. You can only spend this money by going to a laboratory and asking them for help.

But, nevertheless, when that small businessman went to the laboratory and said the castings are falling off of my car—the wheel castings that I'm making for my VW's are falling apart; where are your metallurgists? Well, the metallurgists are experimenting with different viscosity materials in underwater explosive forming. They weren't the least bit concerned about doing any quick and dirty analysis in terms of what's wrong with the wheels. But when they weren't funded to do underwater explosive forming research, but the small businessman came in and said here, I have money to fund your personnel to do the work that I need to have done, it certainly drove the laboratories and some of the universities, in a span of 3 years, to performing that kind of work as needed. So I think we can be much more creative in terms of the institutional incentives.

I think it is much more difficult to change attitudes and incentives on the parts of the individual scientists and the faculty members at the universities and so on, but I think the institutional incentives can be implemented more readily.

Senator DOMENICI. Dr. McTague.

Dr. MCTAGUE. My flip response would be to apply Gramm-Rudman very strongly to the DOE legal staff. [Laughter.]

Senator DOMENICI. I'm afraid, even if we applied it, they would find a way to say they have to fund it and cut something else. But, anyhow——

Dr. MCTAGUE. There was a case of that, in fact, a few years ago when the Packard Commission came in on cutting down bureaucracy and the Grace Commission came in on how to cut down bureaucracy in the Federal Establishment. Well, DOE was told to cut down on paperwork and, therefore, that would reduce the necessity for overhead. There was a mandate to cut—it was called the management efficiency initiative or something to that effect. And they took a half-a-percent out of all of the DOE laboratories, saying "Look, we have decreased redtape, so you're more efficient." And do you know who didn't take the cut? The only people who didn't take the cut were the administrative division of DOE.

Anyway, I agree with what has been stated earlier, especially by Mr. Silva, that local responsibility is the most important issue. Getting control of the process out of Washington is very important. Realizing that we are, indeed, in a situation of experimentation is important, that we all know what the goal is. None of us has a silver bullet to get things done. We must encourage incentives, local risk taking, and also a way to decrease the reliance on secrecy in the laboratories.

Senator DOMENICI. Dr. McConnell.

Dr. MCCONNELL. To a large extent, some of the things we've been speaking of, Congressman, have been techniques. If I had to do only one thing, I would suggest that we raise this activity to the highest level in the Federal labs, appoint the person at the top, give them a sense that this is a serious and important and significant part of their effort, and make certain that it's monitored and that they are rewarded on the same basis that you reward someone who conducts a successful portion of the research activity.

By the same token, I think that private industry needs to develop something—well, bring something to the task that is in rather short supply, and that is vision. They need to recognize that the Federal Government is now willing to let these bits and pieces of technology come to them on an exclusive basis, and hopefully there will be receptor sites—that is to say, individuals or groups in the Federal labs that will be available for immediate and easy contact. And the counterpart in the companies of the United States, receptor sites there as well.

Let me make just one point. I have heard small business a number of times. I think there's a point to be made for large business. The problems that need to be solved in our society are huge problems and small businesses, a single person, a small entrepreneur, is not apt to be able necessarily to solve that. It will require an inflow of cash, a constant inflow of cash, resources that are not available on a small-time basis, and I think that there's long staying power necessary to solve some of our problems. And while I agree that small businesses have a part to play in this, I believe that large businesses as well do.

Senator DOMENICI. Jeff.

Senator BINGAMAN. Let me just ask one question. I'll make it a little convoluted so as to get in six or eight in the middle of it.

The one point that Dean Radosevich was making was that we need to assign more resources to assess the commercial worth of the research going on in the laboratories. And as I understand Dr. McConnell's point that he just made, is that, really we need to give this whole business of getting the research out to the commercial sector a higher priority.

I'd be interested in either of you or anybody else commenting on whether we need to have a designation of an advocate in each laboratory, an advocate for commercialization of research at a high level within the laboratory. If that's something that exists, I'm not aware of it. But is that what you had in mind, Dean Radosevich, with your statement that we need to assign resources to assess the commercial worth of what's going on and to urge that it be commercialized?

Dr. RADOSEVICH. I would say that some disclosures of inventions are fairly easy to determine that they have significant worth. Others, it may be years before a potential user becomes aware of the technology and would discover themselves the possible use for it.

I think the one thing that we don't understand well at all in the process of innovation is how one does, indeed, synthesize the solution—that is, the technology—along with the recognition of the need. There are just a few mechanisms that we employ, such as the industry-laboratory scientist exchange program. Those kinds of mechanisms I think have been used very sparingly and with limited success.

I think the private sector needs to, itself, be more conscious of the kinds of technologies that are available in the laboratory. But that's a very creative process, to synthesize the needs along with the solutions. I don't think we know how to do that well yet. That's why I'm encouraging us to experiment with many, many mechanisms and try to take better account of how they're working or not working so that we can develop ways that we haven't yet discovered at this point.

Senator BINGAMAN. Dr. McConnell, would you have a comment, or any of the rest of you?

Dr. MCCONNELL. No, I think that's correct. I think that—and I'm being a bit redundant—but until this is accepted as a serious and significant charter in the Federal labs, it's going to get this catch-as-catch-can basis activity. It's going to do the same in private industry until they recognize that either there's a success that their competitor has made that they didn't, or that something ends up overseas in one of the companies and they are now forced to compete with a product that comes back to haunt them then when they could have had access to it.

Senator BINGAMAN. Yes, sir.

Dr. MCTAGUE. I think we saw earlier, in a not so disguised fashion, the frustration of the two directors of the weapons laboratories. I don't think it's so much a matter of the government or of anybody else trying to say to them "This is your job." They know it's their job; that's been stated also previously in the Stevenson-Wydler Act, and it was certainly pointed out by the Packard Commission report on the Federal laboratories. They are ready and raring to go. The trouble is that the Washington bureaucracy is getting in their way.

I'd like to emphasize that, in my opinion, technology transfer is a very human activity, as I mentioned earlier. It's not so much a matter of putting patents up for sale. I once headed a facility at a national laboratory, called the National Synchrotron Light Source. I was its first director. That facility now has 700 users, about one-third from industry, one-third from universities, and one-third from various Federal laboratories.

If you want to see technology transfer, some of which was mentioned earlier—for example, this work on x-ray lithography—you just go down and watch what's happening on the floor. You've got all of these people rubbing shoulder to shoulder with each other, and you can bet that they all learn from each other. That's real true technology transfer. It's when you get people communicating directly.

Senator DOMENICI. Well, I think we're going to finish a little bit early, so let me thank everyone, the panel, all the panelists, Senator Bingaman and Congressman Lujan.

Frankly, if you would have asked me the question, Congressman Lujan, it seems to me that what we're talking about in terms of the labs, we all have little ideas on how to do it. But I'm not at all convinced that Dr. McTague is right, that the various statutes have, in fact, effected a policy change as to what the labs are. And I don't believe that's the directors' fault. I think it's ours.

I believe that they remain rather single-mission oriented, and I think those who run them perceive them that way. And I think the only way their asset value will be maximized is if we can possibly, directly or indirectly, make it an absolute policy that they have far more than the mission assigned to them, that the other mission is use of their brain power, give that to anyone that needs it in some orderly manner, emphasize the exchange of information, the availability of the professionals there for advice, and that they are expected to use that talent and resource for applied reasons, applied purposes.

I mean, clearly, it's tough for them because we keep saying they're supposed to. But I'm not so sure that the national government has really said to them "you are, and we will judge you on that basis." Consequently, I think when we say 20 percent, I don't think we should be criticizing the labs at this point. I really don't believe they can do much better until there is a complete change of attitude about what they are. And I think we could do both. I think they can be premier weapons research labs and some other significant thing at the same time. I didn't want to use the word "commercialization" as you used it, commercialization of the labs, although I would buy it. But I think it's too tough to get there. I don't think we could get there.

But it is something inbetween that and what it is that would involve commercialization. We may just have to continue to push around the edges because I don't believe the rest of the Congress would ever let us make those labs that kind of thing. I think they feel that—they have a suspicion that somebody is getting the advantage, some region, some group of citizens, some business group, so I think it'll have to come kind of indirectly. But I don't believe the lab directors can get it done without a change in policy.

I want to again say that we learned a lot; we hope we can effect some change. But overall, we have highlighted the tremendous asset value of the national labs to our region and to our country and, indeed, to the world, and if we can make them even broader in application for both commerce and humanity, obviously we'd all relish spending a lifetime trying to do that. Thank you all very much.

There are some announcements to be made by the chairman, so I'm not going to adjourn. I'm merely going to adjourn this hearing and then we'll turn it over to Fred Mondragon who is the big chairman. He's got some announcements.

We stand in recess.

[Whereupon, at 12:40 p.m., the committees were adjourned.]

APPENDIX

Lawrence Livermore National Laboratory

September 8, 1986

Senator Pete V. Domenici
Chairman, Subcommittee on Energy Research and Development
United States Senate
Washington, D.C.

Dear Senator Domenici:

The Lawrence Livermore National Laboratory has been provided an opportunity to contribute a written statement for the record of the Joint Congressional Hearing on Technology Transfer in Albuquerque, September 4, 1986.

The Department of Energy Weapons Laboratories have an important role to play in the process of transferring federally funded research and development into US industrial products. Together, we, Los Alamos and Sandia, represent a significant portion of federal investment in research and development, and we are custodians of a large technological enterprise of great potential. The current debate over US industrial competitiveness and technology transfer given the need to protect information and technology of importance to national security is a critical one. We, at Lawrence Livermore National Laboratory, are making important contributions to national security, and with only modest effort can do more to assist US competitiveness. The information developed for your hearing will help to achieve the right balance between security and national industrial competitiveness.

The attached statement is prepared for the record of your hearing. We thank you for the opportunity, and hope our statement adds value to the debate.

Sincerely,

Gordon Longerbeam

Gordon T. Longerbeam
Program Leader
Technology Transfer Initiatives Program
Lawrence Livermore National Laboratory

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attachment

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STATEMENT OF THE LAWRENCE LIVERMORE NATIONAL LABORATORY
FOR THE
JOINT CONGRESSIONAL HEARING
ON
TECHNOLOGY TRANSFER
ALBUQUERQUE, N.M.
SEPTEMBER 4, 1986

Technology Transfer has been an important side benefit of research and development at Lawrence Livermore National Laboratory (LLNL) ever since our founding in 1952. The methods by which our technologies have stimulated the private sector are many, but have been dominated by a process which has emphasized public domain considerations rather than industrial competitiveness.

Technology transfer at the Laboratory manifests in many ways: Examples are: 1) intimate contact between private industry and our programs to develop products important to our own success, but also useful to others in various forms; 2) scientific and technical meetings and conferences; 3) consulting for industry; and 4) the formation of new companies from spinoff technology.

For example, we can count at least fifty companies formed from new technologies developed at the Laboratory. Many of these companies are still in business today, with several hundred million dollars in sales, and providing thousands of jobs. Our contributions to the computer industry and those of our sister laboratory at Los Alamos are almost legendary and were the subject of a special meeting of the IEEE Computer Society in Las Vegas recently. We are one of the most prolific sources of scientific and engineering software in the world.

A single LLNL computer program, SCALD, used for computer automated design of electronic circuits, has been the entire basis for the establishment of several California corporations with sales in the hundreds of millions of dollars. In making the prestigious McDonald award to the authors of SCALD, Curt Widdoes and Tom McWilliams, the IEEE cited SCALD as the basis of the Computer Aided Engineering Industry. This technology is a militarily sensitive one and distribution of the software was tightly controlled by the U.S. Navy, sponsors of the research at LLNL. Sales of the industrial products internationally are controlled by the export licensing process.

Our technological leadership in precision machining and metrology has led, either directly or indirectly, to such products as contact lenses, high density computer disks, and VCR's.

It should not be surprising that this process has worked as well as it has. We and Los Alamos are the largest university affiliated, federally funded research and development laboratories in the nation. The three weapons labs are also the three largest national laboratories and together spend more than 2.5 billion dollars a year on research and development. This represents about 15% of all federal funding for research and development spent in government owned laboratories.

One might ask, if the technology transfer process is working this well, then why do anything different? Congress began to recognize the problem before 1980. In passing such legislation as Stevenson-Wydler and Bayh-Dole, Congress concluded that not only was technology transfer less effective than desirable, but that it in fact frequently worked better with foreign concerns than domestic to the detriment of American jobs and US balance of trade. If the problem was difficult in 1980 or 1982, it is worse now, with trade deficits approaching 200 billion dollars.

As we examine our technology transfer record, we find it heavily dominated by the public domain process. That is, few LLNL technologies transferred to private industry were protected by patents or copyrights. Many opportunities for commercialization have been missed for the lack of such protections. Today, we find many in industry who cannot make the significant investment for commercialization of LLNL technology without patent or copyright protection, both domestic and foreign. A current example is a small firm with whom we are involved in the commercialization of remote fiber fluorimetry for biomedical application. This was an invention of one of our staff chemists, the late Dr. Tomas Hirschfeld. A Department of Energy patent was issued on the invention, and the University of California acquired rights to the invention through the normal waiver process. We subsequently negotiated an exclusive world-wide license for the patent with Kelsius, Inc., a small Bay Area firm. Through a work-for-others contract with Kelsius, we assisted the commercialization effort by doing more background research and development at no cost to the Laboratory. Kelsius is now working with a large bio-tech and pharamaceutical firm to handle sales and marketing of the product, which will make important measurements of blood gasses inside human arteries. Frank Antonini, president of Kelsius, has stated that without the patent and exclusive world-wide license, he would not have been able to raise the several million dollars necessary to develop and test the product.

The public domain process has sometimes worked to our disadvantage, as technologies move rapidly across national boundaries, and foreign firms are sometimes more willing than US firms to commercialize technologies funded by US research and development where no patent or copyright protection was available.

As we look to the future, we find many important technologies at LLNL with commercial potential, particularly in materials, microelectronics, software, and biotechnologies. The public domain process will still be in place, but it needs to be supplemented by a managed program of patenting, copyrighting and licensing where domestic economic interests are best served by that process. We are currently seeking waivers on several dozen patents, with commercial potential, and seeking industrial interest in licensing of those patents. We have been able to develop a very cooperative relationship with the University of California in licensing due to our closeness to Berkeley. It should be noted that waivers are requested on a case by case basis, and that on the average, 24 months are required to obtain a waiver for LLNL inventions.

This new technology transfer process will pose no new risks to national security, and may, in fact, enhance it by building the nation's industrial base in new technologies. The vast majority of the work we do at LLNL is unclassified, and we have adequate mechanisms to deal with classified or sensitive technologies, including classified patents, for which waiver will not be sought. There are no priorities at the Laboratory higher than meeting the programmatic commitments we share with the Department of Energy, and protection of sensitive information and technologies. Licensing to industry with a domestic bias can enhance our industrial competitiveness and protect national security, since US industry has rather stringent export license controls placed on it by the federal government.

Erecting new barriers to technology transfer may be particularly damaging in New Mexico, since both labs there are weapons labs. New Mexico has a relatively small industrial base and technology transfer barriers will make an already difficult problem of industrial development even more severe.

In summary, I would like to make the following points:

- Enhancement of national security and US industrial competitiveness requires fewer, not more, barriers to technology transfer. Both arise out of a rigorous industrial base in new technologies which partially result from technology transfer from national laboratories.

- Technology transfer is a very difficult problem. US industry is not beating a path to our door. We need more mechanisms for cooperative effort involving the Lab and industry.

- The Department of Energy weapons labs have adequate mechanisms in place to deal with conflict of interest and classified or sensitive technologies.

- For effective technology transfer with a domestic bias, we need timely mechanisms to take title, in the name of the University of California, to all unclassified and non-sensitive intellectual property at LLNL, including patents, copyrights, and tangible research property such as biological cell lines.

- New Mexico's efforts at industrial development will be particularly hard hit by new technology transfer barriers.

- We need to work harder at more cooperative efforts with the University of California on royalty sharing formulas and on local licensing options in the name of the University. This is particularly important at Los Alamos due to its distance from Berkeley.

Los Alamos
Los Alamos National Laboratory
of the University of California
Los Alamos, New Mexico 87545

November 25, 1986

The Honorable Pete Domenici
U.S. Senate
Dirksen Senate Office Building
Washington, D.C. 20510

Dear Pete:

I am pleased to provide the information you requested during the Joint Congressional Hearing on Technology Transfer held in Albuquerque, New Mexico, on September 4, 1986. As you requested, we have examined ways that the government's investment in research at the DOE national laboratories could be more beneficial to private industry in the United States and improve our economic competitiveness in the international marketplace.

Our recommendations are organized into four specific areas:

1. Continue to Foster "Technology Pull." As noted in my written testimony, "technology pull" has accounted for the greatest portion of the DOE weapons laboratories' impact on commercial technology to date. This form of technology transfer occurs when laboratory research requires new approaches that pull industry into areas of development that subsequently have other commercial application. For example, maintaining our Laboratory's lead in supercomputers, lasers, and accelerator technology can foster the environment necessary for technology pull. This desired climate requires a strong technical staff at the Laboratory and a communication system that promotes the free interchange of information among the scientific, technical, and industrial communities. The Laboratory must have a high degree of administrative flexibility to pursue new areas of science and to form beneficial partnerships with industry.

Our Laboratory has been able to respond to such technical challenges in the past. The special contractual nature of the University of California/DOE management agreement has promoted this. We must be able to avoid the restricting effects of bureaucratic process in order to preserve the proper climate for effective industrial interactions and technology pull.

2. Expand DOE Charter for Technology Development and Transfer for Economic Competitiveness. The United States must make a more concerted effort to encourage technology development and transfer. The DOE national laboratories have played a major role in technology development for energy

and weapons applications. Recent federal legislation has generally endorsed the transfer of appropriate technologies developed for such applications to private industry. This transfer has been somewhat successful, as I pointed out in my testimony. However, to more fully exploit the talent and capabilities of the DOE national laboratories, I believe that technology development and transfer for the purpose of economic competitiveness need to be incorporated more explicitly into the DOE charter.

This extension of the DOE charter is logical because national security depends on economic as well as military strength and a secure energy supply. The DOE has established superb research capabilities at its national laboratories. These research capabilities have been used to extend our basic understanding in the sciences and to apply them in weapons and energy technologies. With relatively minor additional investment by government and private industry, these capabilities could be used to further technologies that will improve our economic competitiveness. The national laboratories in general, and the weapons laboratories specifically, have demonstrated their ability to translate research into products. In today's economic climate, private industry could benefit significantly by investing in research and development (perhaps jointly with government) at the national laboratories. Such investment would especially benefit many medium-size companies that do not have their own research capabilities.

After adding this technology development and transfer role to its charter, DOE should promote vigorously those programs focused on technology and engineering designed to stimulate industrial competitiveness. This revised program should strengthen existing technology transfer activities while seeking new and innovative approaches to stimulate interactions. The recent DOE/steel industry initiative is one good example. I would like to suggest another innovative approach that would establish regional centers for materials synthesis and processing. These centers are research and development areas of high potential for industrial application. The centers would be chartered to work with the commercial sector to develop technologies of interest to industry. The Dutch and the Japanese governments have established similar research centers, targeting materials development as national priorities for economic competition. An investment of approximately $250 million for eight to ten regional centers and an estimated $50 million per year for operation of the centers would provide the United States with a great impetus in this important technological field. The centers would link national laboratories, industry, and universities in cooperative research on topics of national importance, such as ceramics, polymers, composites, and electro-optical materials. These centers could be co-located with many of the excellent basic research and characterization resources (such as neutron scattering, synchrotrons, and electron microscopy centers) at the DOE national laboratories. Close collaboration with universities would assure that the work would have a strong research flavor to bring about new innovations in advanced materials.

Regional centers could also be established for other topics of national importance, such as manufacturing science and technology. These centers would be an investment in U.S. economic competitiveness and economic security.

3. Encourage Entrepreneurial Spinoffs. The creation of new businesses or the enhancement of an existing firm's capabilities is a mechanism of technology transfer that ultimately aims to favorably impact the domestic economy. Interactions with industry have several other benefits. The participating laboratory gains insight into industry needs; industry is exposed to new areas of research; technology with potential commercial application is identified in its early stages, allowing subsequent development to be specifically directed; and new concepts can be stimulated by the interaction between laboratory and industry staff. However, the national laboratories do not presently have the resources nor the charter to develop technologies with potential industry applications from the research stage to the development and early prototype stage. This type of development is often necessary to attract commercial interest. The government could establish a program that links the national laboratories with industry to identify specific research projects with potential for commercial development and to develop those ideas to a prototype stage that has commercial applications. The laboratories' capabilities and expertise could provide the key ingredient for early development of basic research. Costs of development should be charged to or repaid by the industry that picks up the technology. The initial investment could be made by government, some consortium of interested industries, or by a single industry seeking specific development. Once the concept is demonstrated, I believe industry will be eager to invest in such a development program. This program would provide an essential bridge between federal research and the practical applications sought by industry. The number of entrepreneurial spinoffs based on laboratory research should increase as the technologies are at least partially developed before transfer.

4. Create a "Fast Track" for Technology Transfer Arrangements. The policies and procedures of the government agencies should reflect the government's commitment to transferring technology to the private sector. Unfortunately, that is not the case today. Lengthy bureaucratic processes for implementing arrangements are inhibiting the effectiveness of our program, even though the DOE has been supportive of technology transfer in principle and some individuals within DOE have worked diligently to expedite requests for action in specific industrial activities. As we are all aware, companies operating in competitive markets must move quickly to benefit from new technologies. For our Laboratory, the time required to complete contractual arrangements with DOE has been typically one year. We find that companies often lose interest in working with us because this delay is interpreted as a lack of interest in and commitment to technology transfer.

The patent waiver process is equally slow and cumbersome. A typical waiver takes one year for approval. We believe the contracting and patent processes could be completed in 90 days or less if the system were streamlined. We suggest that DOE provide a "fast track" for reaching decisions on collaborative arrangements with industry and on granting patent waivers and licenses. This fast track should be used for all unclassified and nonsensitive technologies from all laboratories. In cases involving unclassified technologies developed in nuclear weapons or propulsion programs, the present case-by-case petition should be continued, but the process needs to be shortened. Approval authority should be delegated to the local DOE operations offices. This delegation would help to reduce decision time and provide close proximity for resolving issues of concern. The ability to process industry requests in a timely manner is crucial to the success of the technology transfer program.

DOE should also be asked to examine its existing policies on patent licensing and royalties to identify innovative arrangements for laboratory/industry partnerships. Potential arrangements could allow DOE and/or the University of California and the Laboratory to share in royalties generated from start-up companies or for the University to accept an equity position in such firms. If desired, limits could be placed on the total income received from such arrangements, with any excess reverting to the U.S. industry.

Finally, the success of technology transfer depends upon the participation and cooperation of many individuals. The legislative branch of government, the executive branch with its federal agencies and laboratories, and industry must all heed the advice you gave during the September 4 hearing: we must be prepared to take some risks to improve our competitive position in today's tough international market.

Thank you for the opportunity to share the Los Alamos experiences in technology transfer. I believe that the recommendations made here would not only help to strengthen the nation's economic competitiveness but also would enhance the vitality of the DOE national laboratories, including the weapons laboratories. We will be pleased to work with you and the DOE to develop any of these ideas.

Sincerely,

S. S. Hecker
Director

SSH/mmr

Irwin Welber
President

Sandia National Laboratories
Albuquerque New Mexico 87185

October 6, 1986

The Honorable Pete Domenici
United States Senate
Washington, D.C.

Dear Senator Domenici:

I am pleased to respond to your invitation at the Focus 86 Hearings on September 4, 1986 to offer suggestions for improving technology transfer from Sandia's point of view as a DOE laboratory operator.

We believe that expanding the scope of technology transfer activities at Sandia would assist the economic development of U.S. industry and thus enhance national security. In particular, the laboratory should be able to patent and license laboratory inventions. Present mechanisms for transferring patents to the laboratory, however, are slow and cumbersome for both the laboratory and the government sponsors.

We therefore support initiatives which will expedite the transfer of patents to the laboratory.

The attached paper entitled "Ways to Improve Economic Competitiveness with National Laboratory Technology" elaborates on this and related concerns.

Sincerely,

October 6, 1986

TO: The Honorable Senator Pete Domenici

SUBJECT: Ways to Improve Economic Competitiveness with National Laboratory Technology

Sandia National Laboratories fully concurs with your observation that the national defense mission of Sandia is paramount and must not be compromised by other activities. We also agree that improving our economic competitiveness is essential to our nation's security. The national laboratories, including those whose mission is primarily defense, can play a broader role in fostering commercial development without sacrificing excellence in defense activity. Indeed, we believe that our suggestions will actually strengthen our defense efforts.

Sandia historically supported technology transfer efforts as a necessary part of the nuclear weapons program. These activities continue today, both as part of the nuclear program and in the energy and non-weapons sectors. Examples include: consultations that may range from mere phone calls to visits of short duration; university interactions on a wide front including use of faculty consultants, contracts for certain research services best done on campus, and granting release time for lab personnel to teach; industrial visits either to or from the laboratory designed to focus specifically on an identified problem; helping staff seek patent rights from DOE to start a business; and sharing of facilities.

We have also shared our technology widely and promptly within the DOE nuclear weapons complex. This sharing is one of many features that contribute to the excellence of our weapons program. And, we share our technology with our suppliers. When a supplier develops and provides a product or service for us, using our technology, the technology, in a very real sense, is transferred to the supplier's facility, where it is available for use in sales to others.

We can readily continue all of the above technology transfer activities without any policy or legislative changes. But full exploitation of our technology will require changes.

In the following discussion, we first examine some matters that need attention. Then we consider some problems that could arise with change. Finally, we offer some suggestions for strengthening our technology contributions and our defense mission. We are confident that the suggestions we make will simultaneously strengthen the flow of laboratory technology to the U.S. commercial sector and encourage even better communication between all of the entities in the nuclear weapons complex.

Let us now examine some of the points that need attention.

First, as noted in our original testimony on September 4, 1986, new technology often develops best when there is exclusivity and fast action. In this context, we emphasized patents and suggested that similar factors arise with respect to copyrights. Some products of laboratory research are developed sufficiently that commercialization can be accomplished with little risk and little further investment. Such developments might best be widely distributed, either through non-exclusive licenses, or by broad publication. On the other hand, there are developments that will require considerable further work and financial risks before giving paybacks to investors; such situations demand some guarantees of exclusivity, at least for a limited period of time. And, it is important to move ahead rapidly if we are to preserve the best opportunities for U. S. enterprise. Our historical methods do not provide the necessary rapid response times.

Second, many questions arise in transferring technology with business potential. Information is needed on whether the technology will work in the competitive commercial market, and assessments are needed of the risks and potential returns. The limits imposed by secrecy associated with national security and possible restrictions on technology exports to certain countries need to be defined. Also, a mechanism is needed to determine what organization can best use the new technology for the economic betterment of the United States. Early resolution of these and other questions is a necessity in today's fast-changing business climate. We need knowledgeable decision makers who can act with the rapidity and flexibility needed in the business world.

Third, in many cases, we expect third parties to work actively with the laboratory in assessing and applying new ideas. Third parties are frequently very helpful in providing information and determining the proper course of action. Third parties may be, for instance, universities, foundations, or consortia of manufacturers. The laboratories would encourage commercialization through or with the help of third parties by arranging for patent licenses and technical expertise as necessary. Proximity to third parties as well as inventors and local and national businesses, and developing familiarity with business considerations relevant to a particular technology are essential in making good licensing decisions.

Fourth, we believe the laboratories are best qualified to choose, work with, and support third parties and domestic manufacturers to carry development forward. At the same time, we recognize that the decision-making process will have to adhere to certain principles associated with the nature of government-funded work. We are confident that these principles can be accommodated. Thus far, Sandia has not been able to obtain waivers giving the laboratory itself rights to inventions with which Sandia can license others. We understand DOE is addressing this matter. Waivers to the laboratories are essential to working effectively with third parties and domestic manufacturers.

Fifth, the Government's principal purpose for acquiring patents is defensive, i.e., to protect the government's right to use technology developed at public expense. Use of Government-acquired patents as commercial tools to promote economic growth is a secondary consideration. Under an effective process for promptly translating new ideas into patent disclosures and granting exclusive rights, the laboratories, in concert with the Government's patent needs, can determine the purpose and scope of patent protection, whether to seek domestic and foreign patents, how fast to pursue protection, and how to distribute and pace patent expenditures. And, the results will be conducive to commercialization.

Sixth, outside of patents, we have no mechanism for insuring that U.S. industry gets first crack at know-how, which can be more significant than patent rights. Provisions for selective transfer of this class of information could be valuable to U.S. industry.

In addition to outlining matters that need attention, we should anticipate and deal with any new problems that could arise from suggested policy changes.

1. Some fear that giving more authority to the laboratories in handling patent matters and commercially useful data might hinder inter-laboratory communication in the sense that industrial firms protect data in competitive areas. If such were to occur, it would be particularly harmful in the integrated weapons

complex that comprises a large part of the DOE operations. However, patents are a way to communicate. They are a disclosure-favoring concept in the law. Encouraging rapid disclosure and filing for patents would result in better communications. If we require that patent disclosures be shared widely in the weapons complex, we would actually improve communications.

2. Another fear is that the dissemination of classified data to unauthorized recipients might be encouraged as a result of incentives to emphasize commercialization of technology from the weapons complex. However, in the weapons laboratories, there is a strong tradition of placing security first. This is supported by effective classification procedures at the laboratories, DOE operations offices and DOE headquarters. All publications from the weapons laboratories pass through the laboratory classification system and special problems or "gray" areas that may be difficult to judge based upon the published Classification Guidelines are referred to the DOE operations office or headquarters for decisions. This multi-tiered system has worked well for decades. Patents are another class of publications that pass through the same review system, and there seems to be no new risk. Indeed, national security would be well served by more emphasis on patents because this is a way to encourage retention of commercially important technology for U.S. benefit.

   In those instances when sensitive (unclassified) information arises in our technology transfer program, we carefully select recipients that will handle the information in accord with federal regulations which require licenses and review before such information can be exported.

3. There are some who believe that giving more authority to the laboratories to license commercially-useful technology could result in abuses or conflicts on the part of the laboratories. This concern is misplaced. First, the laboratory would not be directly involved when exclusive patent rights are granted directly to the operator of the laboratory to use in its separate

commercial operations. Second, as stated above, the laboratories' role could include that of facilitator, to support the licensing and commercialization efforts of third parties. Third, royalties received by the laboratories could provide added support for laboratory programs that DOE authorizes.

4. There are concerns that granting exclusivity to technology could result in keeping valuable assets from the market place if the grantee fails to commercialize the technology. Presently, the government waiver process includes "march in" provisions that allow invention rights to be reassigned in those cases when development is not progressing. Federal laboratories should include this provision in any licenses they negotiate. In addition, the Government should continue its practice of retaining rights for its own use. If the laboratories could negotiate technology commercialization agreements with third parties and others, the likelihood of rapid development would increase, owing to the closer relationships attending decentralized management. March-in provisions would be more promptly enforced when needed.

We offer the following suggestions at this time, which we believe will strengthen technology contributions to the commercial sector and the defense missions of the laboratory.

- Implement changes to promptly provide exclusive rights to patents, including, as one possibility, to the operator of the laboratory, AT&T in the case of Sandia.

- Decentralize granting patent rights, using criteria for deciding whether granting exclusive or non-exclusive rights will best serve the national needs.

- Within broad guidelines, allow the laboratories to institute individual programs for technology transfer and commercialization by others.

- As appropriate, seek patents from the vantage point of both defensive patenting to protect the government's right to use the technology, as well as commercial value.
- Institute a review process to quickly consider granting rights to technology that may lie in a "gray" area, on the fringes of secret information. This process should apply the present infrastructure used in classification matters. It should be understood that this must not interfere with our primary national defense mission and security interests.
- While working to optimize policies for the long term, identify one or more particularly promising technologies and "fast track" these rapidly from initial disclosures by the inventor through patenting and licensing.
- Encourage the continuation of technology transfer activities that utilize unique laboratory skills to aid both private and public institutions. These programs are successful and must not be eclipsed by licensing programs.

We should be mindful that the business world is full of uncertainties. Many new businesses fail and many new and apparently useful products never find their way to market. Merely delegating more authority to the laboratories is no guarantee of success, but failing to delegate authority to those who can act most promptly and knowledgeably might result in failures. We should strive for a flexible system that can tolerate different approaches for diverse technologies and markets.

Sandia National Laboratories

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